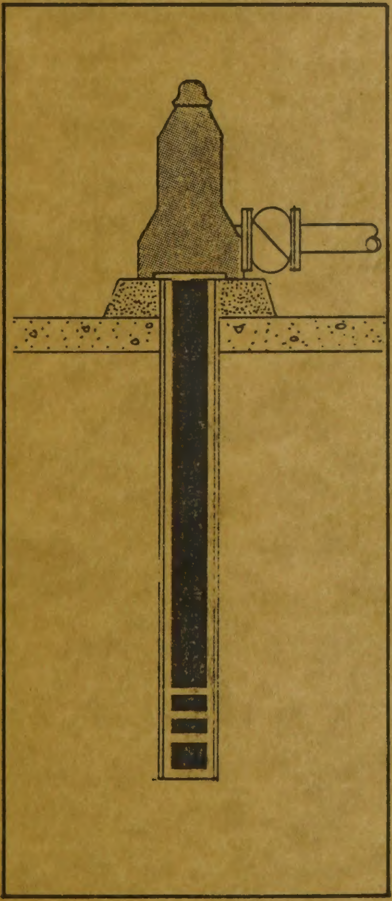
EVALUATION OF WATER SUPPLY ALTERNATIVES FOR THE CITY OF HELENA, MONTANA



GUARDIAN OF THE GULCH

City of Helena

PREPARED BY:

HYDROMETRICS

CONSULTING SCIENTISTS & ENGINEERS

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August 3, 1984

REPORT AND RECOMMENDATIONS OF

THE GROUNDWATER FEASIBILITY STUDY COMMITTEE

Prepared for:

The Helena City Commission

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Summary

The Groundwater Feasibility Study Committee has worked with Hydrometrics and City of Helena staff members for the past several months. The committee was originally established by the Helena City Commission to aid in the investigation and evaluation of potential groundwater supply sources for the City. Over the course of the investigation, however, the role of the committee has been expanded to include evaluation of all water supply alternatives available to the City of Helena.

The committee recognizes that hindsight is always 20/20 and has little interest in providing commentary on past decisions that might seem to be in error at this point in time. However, we feel it is appropriate to make note of several points that have arisen during our study that we think are cause for concern. Some of those points would include:

1. The population figures used in the Water System Master Plan were too high.
2. Water use projections of the Master Plan were too high.
3. Groundwater was not adequately investigated prior to the expansion and remodeling of the Missouri River Treatment Plant (MRTP).
4. More reasonably priced alternatives such as direct filtration and package plants have not been adequately investigated for use on the Ten Mile system.
5. Cost estimates for a Ten Mile plant appear to be very high in comparison with similar cost estimates and recent construction of plants at other locations.
6. The Missouri River Treatment Plant has been expanded in spite of the concerns of the Montana Department of Health and Environmental Sciences (public health concerns of Ten Mile), the Montana Consumer Council and the Public Service Commission (high costs).

In conclusion, we commend the Helena City Commission and the City of Helena's professional staff for allowing concerned citizens and agencies a voice in determining the future of the city's public water supply system. We earnestly hope our recommendations will be of value, and we remain willing and eager to provide additional input if requested to do so.

Recommendations

1. Preparation should begin immediately to conduct a pilot plant study on the Ten Mile system. We feel the fresh outlook and open-mindedness displayed by Hydrometrics during the preparation of its "Evaluation of Water Supply Alternatives for the City of Helena, Montana" have proven to be of major benefit to the city, and the committee makes the recommendation that the city contract with Hydrometrics to:
   - (a) Assist in the preparation of a Request for Proposals (RFP) and assist in the selection of a firm to conduct the pilot study,
   - (b) coordinate the study, and
   - (c) review and coordinate the selected firm's report which will include cost estimates and recommendations to the city and this committee at the conclusion of the study.

   The pilot plant study should be designed to:
   - (a) determine if direct filtration is appropriate for two options -- where Chessman and Scott are used and where Chessman would not be used;
   - (b) provide data for design purposes (including taste and odor control);
   - (c) determine effectiveness for giardia control.

   Detailed cost estimates should be prepared for each option including:
   - (a) direct filtration;
   - (b) conventional treatment;
   - (c) a phased conventional plant in which the direct filtration portion would be constructed first and in such a manner that the remainder of the conventional treatment processes could be added if and when they were proven to be necessary;

(d) package plants.

2. This committee feels the city should immediately take steps to establish water rights for groundwater in the Helena valley and to make a more exact determination of the cost and feasibility of groundwater as an integral part of the Helena water supply system. We are aware there is some risk associated with groundwater development, but in view of the fact that:

   (a) the lowest cost option appears to be the use of a Ten Mile plant (without Chessman and the 24" transmission line) and groundwater for peaking purposes with an adequate supply; and

   (b) "development of groundwater may be foregone if not begun before continued development in the valley results in the likelihood of significant water rights conflicts" (Hydrometrics' report), it is our opinion the risk is warranted.

   Two to four high capacity test wells should be developed near the Missouri River Treatment Plant (MRTP), the MRTP transmission mains, or the MRTP raw water line. These wells should be properly constructed so they can be used for production wells after approval of the appropriate regulatory agencies.

3. Two members of this committee should be part of the consultant selection committee.

EVALUATION OF WATER SUPPLY ALTERNATIVES FOR THE CITY OF HELENA, MONTANA

- FINAL REPORT -

for

City of Helena
316 Park Avenue
City/County Building
Helena, Montana 59623

by

HYDROMETRICS
2727 Airport Road
Helena, Montana 59601
406/443-4150

August 1984

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120 S. Last Chance Mall
Helena, Montana 59601

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SUMMARY

Hydrometrics has worked in conjunction with the Groundwater Study Committee to investigate potential groundwater supply sources for the City of Helena. Geologic investigations and test well drilling in the Tenmile Creek drainage and in the West Valley have shown that these two areas do not have sufficient groundwater development potential to benefit the City of Helena's supply system. During this investigation, the Committee redirected the focus of the study from analysis of groundwater potential and costs to an evaluation of a variety of water supply options for the City of Helena. Potential water supply sources for the City of Helena are:

1) Groundwater from a Central or East Valley source,
2) The Missouri River Treatment Plant,
3) Tenmile Creek surface water.

The various water supply options evaluated are combinations of two supply sources using one source as the primary supply and another as a secondary or peaking supply to provide for a peak demand of 20 million gallons per day (MGD). Cost analysis indicates there is very little cost difference among the primary alternatives. The most promising alternatives appear to be:

1) Primary source - 10 MGD Tenmile Treatment Plant (without Chessman repairs). Additional 1 MGD supplied by storage.

Secondary source - Missouri River Treatment Plant (9 MGD)

Capital cost $8,243,000 Adjusted Annual Cost $2,734,105

2) Primary source - 10 MGD Tenmile Treatment Plant (without Chessman repairs). Additional 1 MGD supplied by storage.
Secondary Source - Groundwater system using Missouri River Treatment Plant pipelines (9MGD). Missouri River Plant may be needed to supply the peaks.

Capital Cost $9,445,163 Adjusted Annual Cost $2,688,530

3) Primary Source - 11 MGD Tenmile Treatment Plant (with Chessman repairs).
Secondary Source - Missouri River Treatment Plant (9 MGD)

Capital Cost $9,575,000 Adjusted Annual Cost $2,888,586

Annual and peak day demands for the City of Helena water supply service area were determined based on current projected growth information and past system water usage. A peak system demand of 20 MGD (exclusive of the Hale/Eureka system) is projected for the year 2007. A number of conservation and system reduction alternatives were evaluated to see if they would provide cost-effective means for reducing peak system demands. Although conservation methods may reduce total system water use, they have little effect on peak demands. The only potential method for significantly reducing peak demands appears to be system management or water rationing directed at summer irrigation use.

System design size may be reduced by the efficient use of existing and additional in-town storage. Potential cost-reductions to a Tenmile Treatment Plant could come from using storage to supplement peak demands. Another potential savings would come from the use of direct filtration rather than the proposed conventional treatment plant design. Although there is no assurance a direct filtration plant would work for the Tenmile system, the potential for significant cost savings warrant a further evaluation and possibly a pilot plant trial.

Development of groundwater to supplement the Missouri River Treatment Plant would be cost-effective if wells could be drilled near the existing plant or lines. Development of groundwater may be forgone if not begun before continued development in the valley results in the liklihood of significant water rights conflicts.

INTRODUCTION

At the request of the City of Helena and under the direction of the Citizen's Groundwater Study Committee, Hydrometrics has completed a feasibility study to evaluate water supply alternatives for the City of Helena. This study was approved by the Helena City Commission September 12, 1983. The City of Helena is required by the Montana Department of Health and Environmental Sciences to have an upgraded Tenmile Creek or alternate supply source on line by 1987. The initial scope of the investigation was to determine if groundwater development in the Tenmile Creek or Helena Valley is feasible and to compare costs with proposed construction of a 15 MGD (million gallons per day) conventional surface water treatment plant on Tenmile Creek. However, as the study progressed the scope of the investigation was broadened to evaluate other water supply options in addition to groundwater and the Tenmile system. The scope of the final phase of the study, involving detailed cost comparisons and a system analysis, was delineated at the April 26, 1983, meeting of the Groundwater Study Committee. A brief history of this project is as follows:

July 28, 1983	Final Phase I Groundwater Assessment Report accepted by Committee.
September 12, 1983	City Commission Approves Phase I and Authorizes Phase II
November 30, 1983	City obtains easement with RV Ranch for drilling test holes near Tenmile Creek
December 5-12, 1983	Test wells drilled in Tenmile study area.

February 3, 1984	City obtains easement to drill test wells at Green Meadow Country Club.
February 17-21, 1984	Test wells drilled at Green Meadow Country Club.
March 15, 1984	Hydrometrics report to Committee on test drilling results and committee defines 15 MGD plant for cost comparison.
April 26, 1984	Hydrometrics report to Committee on 15 MGD cost comparison and Committee request for expanded analysis of water supply options.

Morrison-Maierle-Montgomery provided assistance with projected water demands, Tenmile drainage, water availability, cost estimates and effects of increased storage. The final scope of this investigation included four components. These are:

1) Assessment of the Upper Tenmile drainage for groundwater development;

2) Assessment of the West Valley area for groundwater development;

3) Cost comparison between a 15 MGD Helena Valley groundwater system versus a 15 MGD Tenmile surface water system;

4) Analysis and comparison of a smaller groundwater system and Tenmile treatment plant options, and other alternatives, including conservation, a direct filtration plant, removal of large users from the system and the effects of increased water storage.

GROUNDWATER AVAILABILITY ASSESSMENT OF THE UPPER TENMILE CREEK AREA

The first phase of the investigation was to evaluate the availability of groundwater in the upper Tenmile Creek Valley (Figure 1). This involved review of existing geologic data, a seismic refraction survey to estimate the depth of alluvium and the drilling of three test wells. The advantage of developing a groundwater source in the upper Tenmile Valley is that it could potentially replace Tenmile Creek surface water and utilize the existing supply lines to supply the Upper Malben-Woolston zone. As described in the Phase I Assessment of Availability of Groundwater for Municipal Water Supply (Hydrometrics, 1983), little hydrogeological information was available on the upper Tenmile Creek area and groundwater development would probably depend upon geologic conditions suitable for a collector well system.

UPPER TENMILE HYDROGEOLOGY

Tenmile Creek is a northerly flowing, high energy mountain stream incised in a narrow valley until it reaches the broad relatively flat valley near the City of Helena settling basin. Tenmile Creek flows in an easterly direction for about three miles from its confluence with Sweeny Creek before again entering a narrow incised valley section (Figure 1). The broad valley bottom along this reach of Tenmile Creek is about one mile wide and three miles long and is the focus of this phase of study. Although several shallow wells of moderate capacity (200 to 300 gpm) exist along the Tenmile Creek channel, little information was available on the hydrogeological conditions in this broad

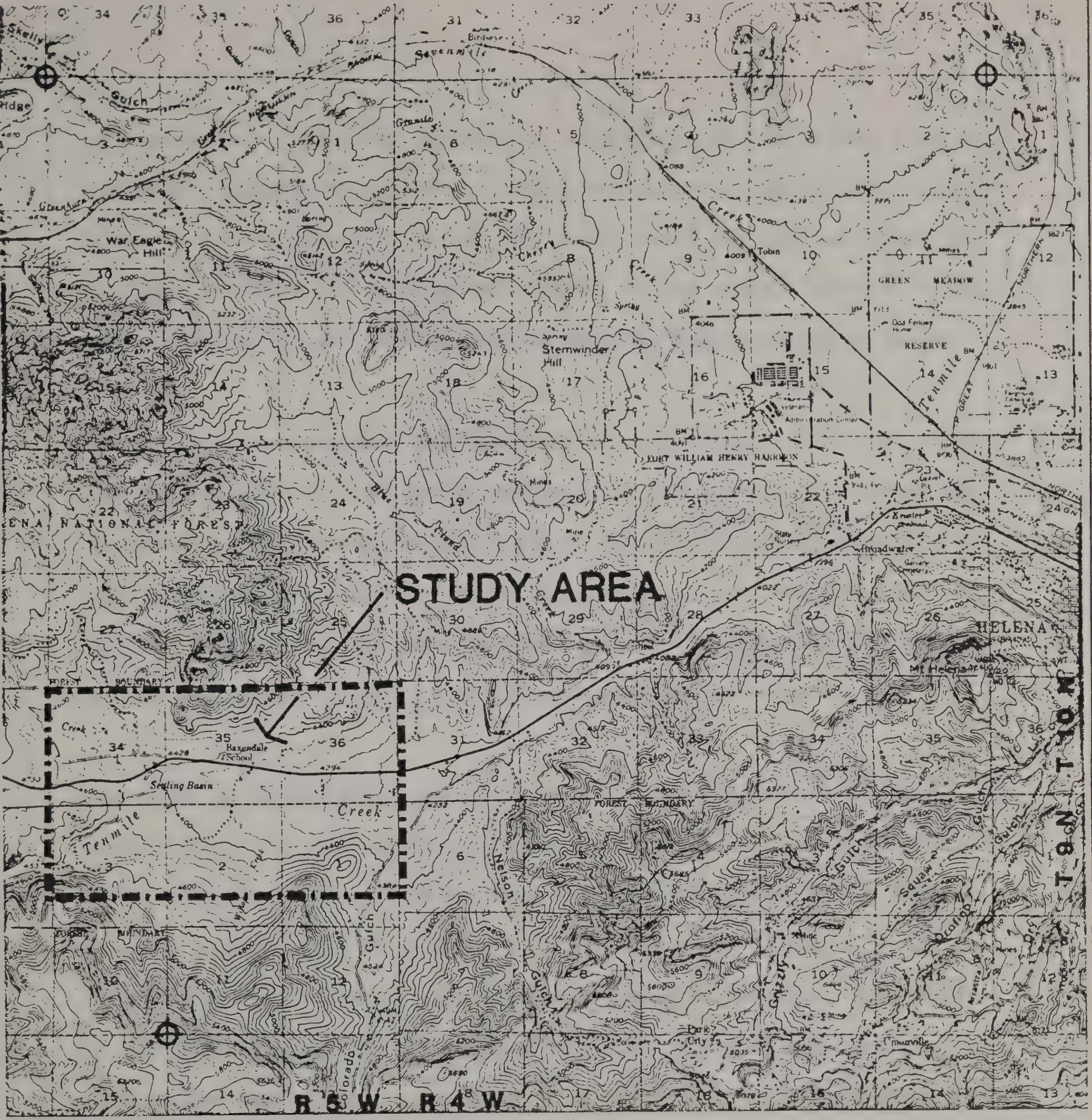


FIGURE 1

GROUNDWATER INVESTIGATION SITE

NEAR TEN MILE CREEK SETTLING BASIN

PREPARED BY: HYDROMETRICS

valley section. Shallow bedrock is present along the valley margins north of Highway 12 and also along the southern side of the valley where a gentle break in slope appears to mark the edge of alluvium. Numerous boulders and cobbles are visible on the ground surface in the valley bottom in the vicinity of the settling basin and the RV Ranch.

Abandoned stream channels and apparent levee deposits are common across the entire width of the valley bottom. In the western portion of the study area the present stream channel follows the north edge of the valley bottom and flows on bedrock in several places near the settling basin. Downstream, the Tenmile Creek channel is closer to the center of the valley and flows in a gravel and cobble lined channel.

The Tenmile Creek Valley contains unconsolidated alluvial valley fill underlain at shallow depths by sedimentary and igneous bedrock. Unconsolidated alluvium in the study area was deposited primarily by Tenmile Creek. Sweeny Creek is tributary to Tenmile Creek in vicinity of the settling basin (Figure 2). Alluvium is exposed to an approximate depth of 15 feet in a gravel pit east of the settling pond and consists of silty sands and silty, sandy gravel layers with no clean gravel zones observable.

The only high capacity well inventoried in the immediate study area is a dug well adjacent to the Tenmile settling basin in Section 34 (T10N, R5W) used by the City of Helena for municipal water (Figure 2). This

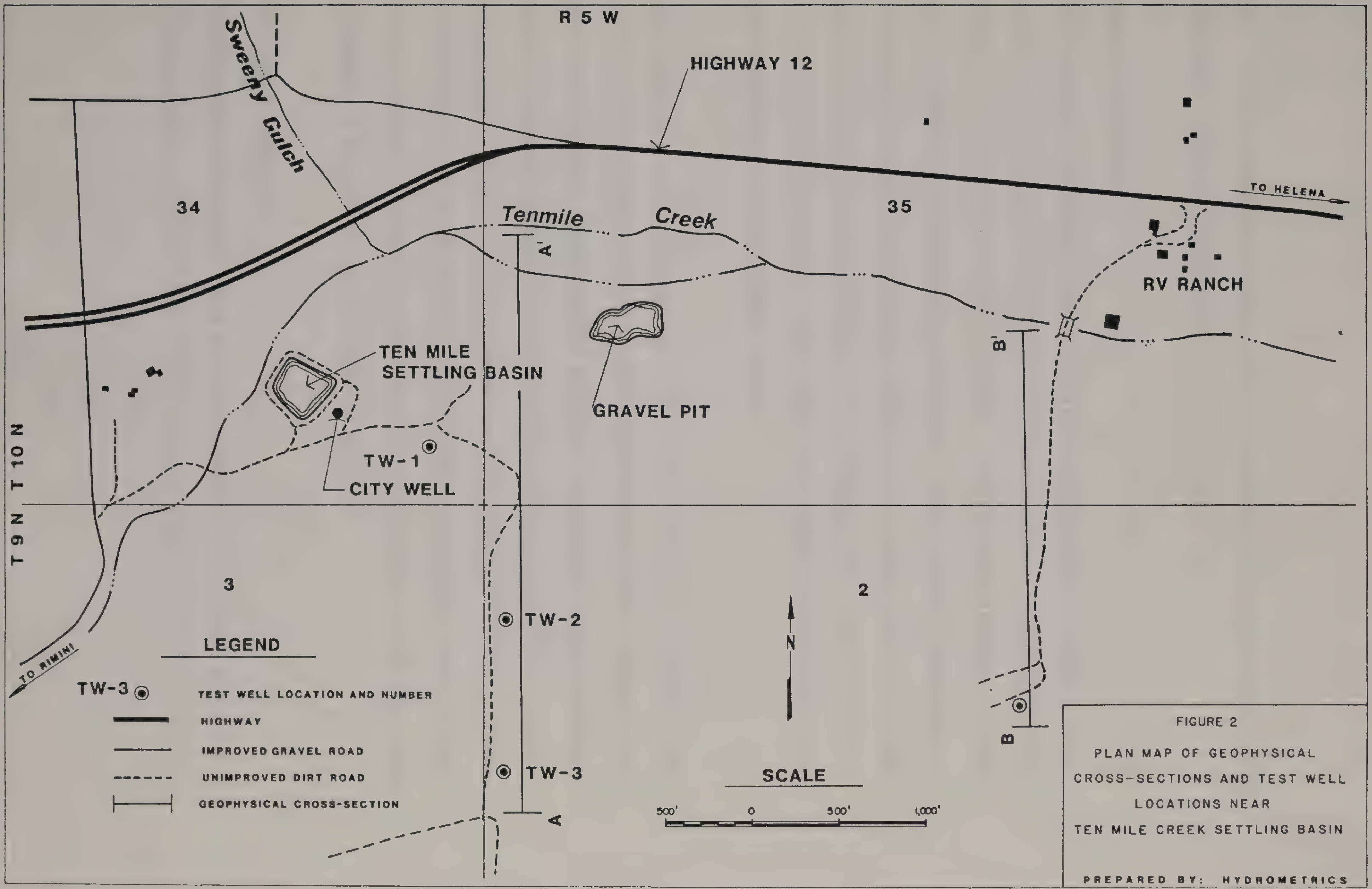


FIGURE 2

PLAN MAP OF GEOPHYSICAL CROSS-SECTIONS AND TEST WELL LOCATIONS NEAR TEN MILE CREEK SETTLING BASIN

PREPARED BY: HYDROMETRICS

well is 60 feet deep, has a static water level of 50 feet, and reportedly yields 200 gallons per minute (gpm).

SURFACE GEOPHYSICS

The seismic refraction method was used to determine thickness and areal extent of alluvium in the Tenmile Creek Valley. This geophysical method utilizes the fact that seismic waves travel through different earth materials at different velocities. When seismic waves cross a lithologic boundary into a denser material, the wave velocity increases and the wave paths are refracted. The seismic waves are initiated by an energy source which, in this case, was simply a hammer blow on a steel plate set on the ground surface.

Two geophysical cross sections were conducted across Tenmile Creek Valley; one near the present Tenmile Creek settling basin and the other near the RV Ranch approximately 3000 feet downstream from the settling basin (Figure 2). Results of both cross sections show depth to bedrock to be about 40 to 50 feet across most of the valley (Table 1). Depths to bedrock of about 60 feet were calculated in several places on each cross section. Figure 3 shows depth of alluvium in the two cross sections as determined by the seismic surveys.

TEST HOLE DRILLING

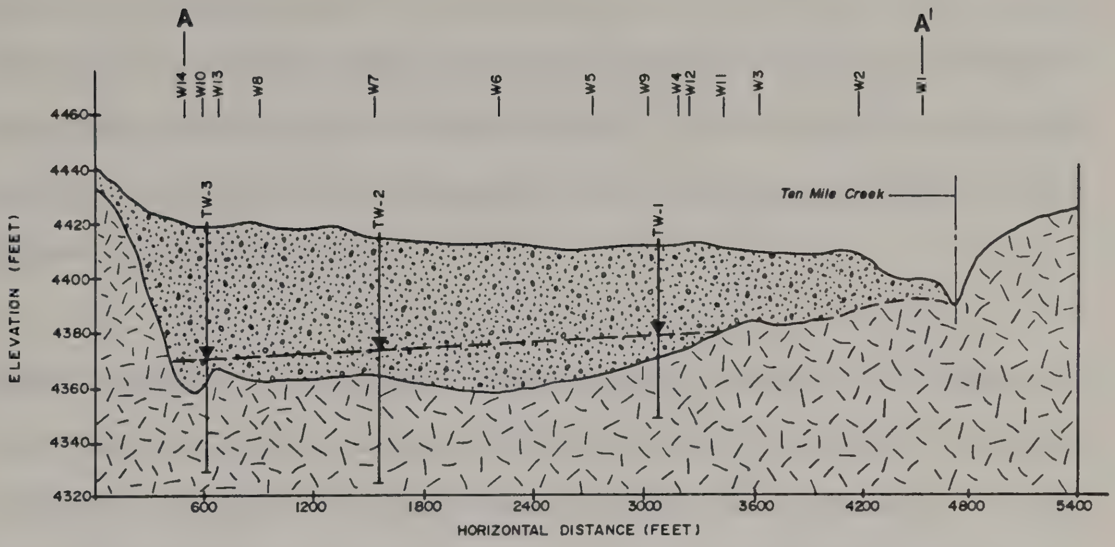
Three test holes (TW-1, TW-2 and TW-3) were drilled across the Tenmile Creek Valley in the vicinity of the Tenmile Settling basin (Figure 2).

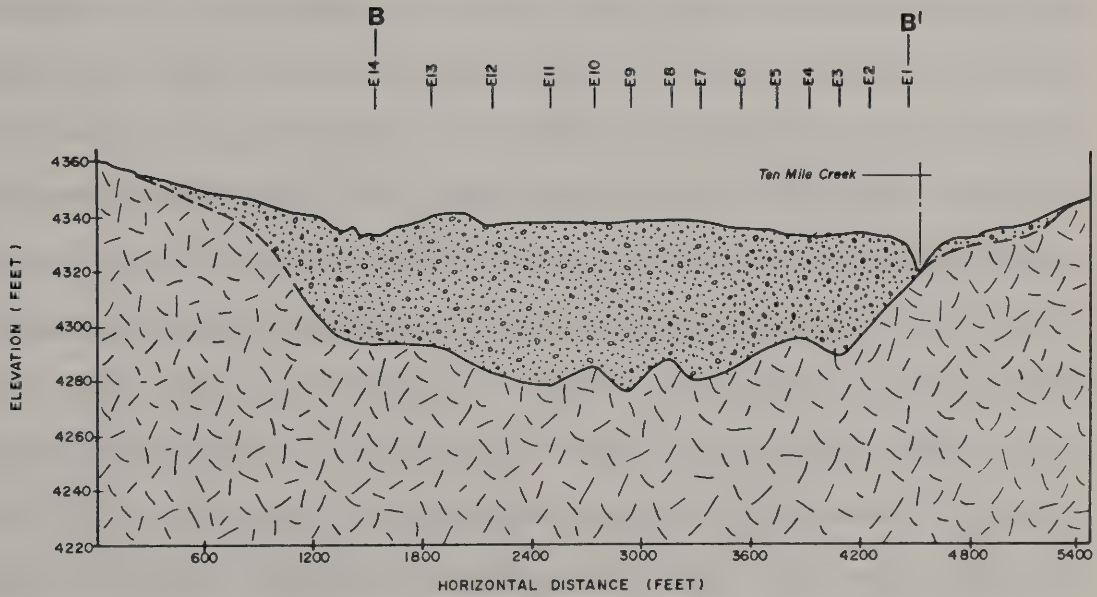
TABLE 1. DEPTH TO BEDROCK DETERMINED FROM SEISMIC SURVEYS NEAR TEN MILE CREEK SETTLING BASIN

Upper Cross Section (A-A')		Lower Cross Section (B-B')	
Site	Depth to Bedrock (ft)	Site	Depth to Bedrock (ft)
W-1	23	E-1	15
W-2	-	E-2	35
W-3	24	E-3	46
W-4	39	E-4	36
W-5	45	E-5	40
W-6	54	E-6	48
W-7	49	E-7	59
W-8	55	E-8	51
W-9	40	E-9	61
W-10	60	E-10	52
W-11	28	E-11	60
W-12	38	E-12	56
W-13	50	E-13	47
W-14	58	E-14	41

Notes:
1. See figure 3 for site locations and cross sections.
2. Seismic refraction method was used with a hammer and steel plate.
3. Bedrock at proposed plant site is less than 12 feet.

TEN MILE UPPER CROSS-SECTION





TEN MILE LOWER CROSS-SECTION

LEGEND

TW-1 TEST WELLS

W2, E12 SEISMIC SITE

▨ ALLUVIUM

▨ GRANITIC BEDROCK

—▼— APPROX. WELL WATER LEVEL (JAN. 1984)

NOTE: ELEVATIONS ESTIMATED FROM USGS, 1:62500, HELENA, MONTANA

NOTE: SEE FIGURE 2 FOR CROSS SECTION LOCATIONS

FIGURE 3

TEN MILE CREEK UPPER AND LOWER CROSS-SECTIONS

PREPARED BY: HYDROMETRICS

Data from these holes agreed closely with the geophysical cross sections. Completion/lithologic logs for the three wells are in Appendix 1. The holes were drilled by Lindsay Drilling in December 1983 under the supervision of Hydrometrics. A rotary drilling rig with top-drive casing hammer was used to drill the holes and drive 6-inch diameter steel casing.

Depth to bedrock in the three holes ranged from 47 to 57 feet below ground surface. Alluvium generally consists of coarse-grained sand with silt, gravel and boulders of igneous lithology. These unconsolidated deposits produced very little water during drilling. A maximum of a few gallons per minute could be continuously blown from any of the holes using the drilling rig. Granitic bedrock (quartz diorite) was encountered in each hole directly below the alluvium. The northern-most hole (TW-1) encountered fresh, hard granitic bedrock, whereas the other two holes (TW-2 and TW-3) encountered weathered, decomposed granitic bedrock. The three holes were drilled up to 40 feet into bedrock. Little or no water was produced from either alluvium or bedrock in each hole. Static water levels measured in wells TW-1, TW-2 and TW-3 are approximately 30, 38 and 46 feet below ground surface, respectively (January 20, 1984). The relationship of depth to groundwater, valley fill alluvium and bedrock in the upper cross section near the settling pond are shown in Figure 3.

SUMMARY OF TESTING RESULTS

Results of the seismic survey and the three test holes drilled in the

alluvium of upper Tenmile Creek indicate that potential for development of groundwater for a municipal supply system near the Tenmile Creek settling pond is very poor. Limited saturated thickness of alluvium and low permeability restrict the potential for development of groundwater to wells with low to moderate yields near the Tenmile Creek channel. In addition, the low permeability of the upper Tenmile Creek channel alluvial materials severely limits the possibility of developing an effective collector well or infiltation gallery system. No further hydrogeologic or cost assessment work on groundwater development in the upper Tenmile Creek basin is recommended.

WATER AVAILABILITY ASSESSMENT OF THE WEST VALLEY AREA

After completion of the upper Tenmile Creek phase of the groundwater investigation, Hydrometrics was directed by the Groundwater Study Committee to investigate the availability of groundwater in the West Valley (Green Meadow Country Club) area (Figure 4). The assessment involved evaluation of existing geologic and hydrologic data and drilling of two test wells. The advantage of using groundwater in this area is that the existing Tenmile Creek supply lines are only a short distance away. However, groundwater from this area would have to be pumped to the City's reservoir system. Total lift would be about 400 feet assuming a pumping level 75 feet below ground surface. As indicated in the Phase I report (Hydrometrics, 1983), a major constraint to development of a municipal groundwater supply in the West Valley is the shallow depth of alluvium.

HYDROGEOLOGY

The West Helena Valley in the vicinity of Green Meadow Country Club is a broad, flat flood plain adjacent to Tenmile Creek (Figure 4). This area is just northeast of where Tenmile Creek leaves a narrow valley in the mountains and enters the Helena Valley. Geologically, surficial materials consist of Quaternary channel alluvium and floodplain deposits underlain by Tertiary "lake bed" sediments or older bedrock material at depths generally ranging from 50 to 150 feet. Groundwater is shallow in this area and there are numerous springs, ponds and

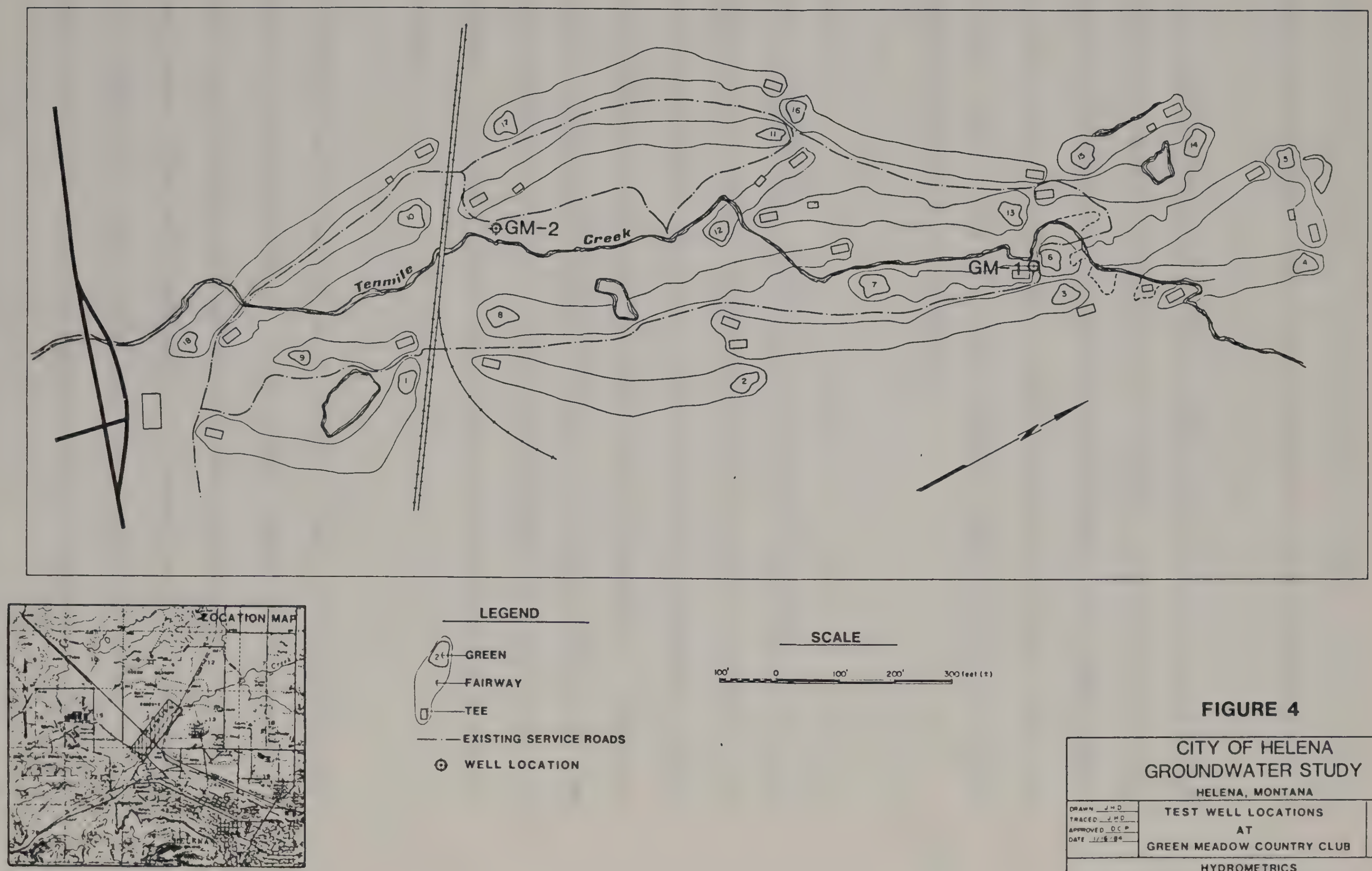


FIGURE 4

CITY OF HELENA
GROUNDWATER STUDY
HELENA, MONTANA

DRAWN JHD
TRACED JHD
APPROVED DCP
DATE 1/16/84

TEST WELL LOCATIONS
AT
GREEN MEADOW COUNTRY CLUB

SHEET NO

HYDROMETRICS
CONSULTING SCIENTISTS AND ENGINEERS

groundwater drain systems. The groundwater system in this area is recharged by infiltration from Tenmile Creek and from irrigation.

Due to the shallow groundwater table, much of the area is undeveloped resulting in limited groundwater use. However, there are a few high capacity wells with yields as high as 500 gpm. The Green Meadow Country Club and the Woolston wells produce 450 and 330 gpm, respectively. These wells are large diameter (about 30 feet), shallow and presently are used for irrigation.

TEST WELLS

Two test holes (GM-1 and GM-2) were drilled on Green Meadow Country Club property near Tenmile Creek (Figure 4). Test well locations were chosen to supplement existing data available from well logs. Completion/lithologic logs for the holes are in Appendix 1. The test wells were drilled by Lindsay Drilling in February 1984 under the supervision of Hydrometrics. A rotary drilling rig with top-drive casing hammer was used to drill the holes and drive 6-inch diameter steel casing.

Unconsolidated alluvium consisting of gravel, sand, silt and clay was encountered in the two holes. This gravel material is generally coarse-grained, sub-rounded to angular, and consists of argillite, limestone, quartzite and a variety of igneous rocks. The gravel contains a matrix of sandy silt and clay. Bedrock in well GM-1 consisted of quartzite and was encountered at a depth of 156 feet.

Granitic bedrock was reached in well GM-2 at a depth of 135 feet. It is estimated that each of these two wells would yield approximately 50 to 100 gallons per minute (gpm) from unconsolidated alluvium if the wells were properly screened or perforated. However, these unconsolidated deposits contain sufficient clay which severely limits the ability of the aquifer to yield large quantities of groundwater to wells.

SUMMARY OF TESTING

Based on results from the two test wells and from evaluation of data from existing wells in the area, it appears that conventional wells or collector type wells would not provide sufficient water for Helena's municipal supply. The West Valley area is limited by the thickness and low transmissivity of the unconsolidated alluvium. Additionally, seepage available from Tenmile Creek is insufficient to rapidly recharge the groundwater system. Although local areas suitable for developing high yield wells may exist they most likely are of relatively small areal extent. Development of a groundwater supply of sufficient quantity and reliability for a municipal supply does not appear to be feasible in the West Valley area.

CENTRAL AND EAST VALLEY DEVELOPMENT POTENTIAL

The potential for development of groundwater in the central or eastern part of the Helena Valley was described by Hydrometrics in the June 1983 report to the City of Helena. Additional work on assessment of these areas was not conducted as part of this investigation. In summary, the central part of the valley contains extensive alluvial deposits and furnishes water to numerous wells in the area. There are a few high capacity wells in the Central Valley area that yield as much as 950 gpm. Near interstate highway I-15, there are only a few wells and the groundwater development potential is unknown. Groundwater is recharged in this area from infiltration of streams and irrigation water. The potential for development of municipal high capacity wells for municipal purposes would require a detailed hydrological study and test drilling. Overall, the potential for development of water supply wells is fair. Major groundwater development constraints in this area are presence of numerous private wells and limited area of known strata capable of yielding large quantities of groundwater.

The East Valley area contains unconsolidated alluvial deposits derived primarily from Prickly Pear Creek. The alluvium contains considerable groundwater and a number of high capacity wells. The potential for furnishing water for municipal purposes in this area is very good; however, a detailed hydrogeological investigation and test drilling would be required to define the groundwater system and determine the best development plan. Location of wells to avoid conflicts with

existing groundwater users would be an important consideration in development of East Valley groundwater.

GROUNDWATER DEVELOPMENT REQUIREMENTS

The original scope of the groundwater investigation included outlining the requirements for development of a municpal groundwater supply. This included a timetable that would be involved if the city decided to develop groundwater for Helena's water supply needs. The following description outlines the applicable rules and procedures required for developing a public water supply from groundwater. The Water Quality Bureau of the Montana Department of Health and Environmental Sciences regulates water supplies used for public purposes and the Montana Department of Natural Resources and Conservation (DNRC) administers water rights laws. The responsibility of the Water Quality Bureau is to ensure water is supplied in adequate quantities and that the water meets all quality standards. Additionally, the Water Quality Bureau is responsibile for review of the water system plans and specifications to verify that the planned engineering and construction meet appropriate engineering standards. The Water Quality Bureau also has the regulatory responsibility for periodic testing of water quality and for periodic inspection of the facilities to confirm that water system are properly operated and maintained.

The regulatory framework of the Water Quality Bureau for public water supplies consists of Montana Laws Regarding Public Water Supply (Title 75, Chapter 6, Part 1, MCA) and regulations pursuant to this Act. Regulations applicable to groundwater development for municipal water supples are:

1) Public Water Supplies (ARM 16.20.201 through 16.20.307)

This regulation defines water quality standards, chemical and bacteriological testing, testing and sampling records and provides reporting and notification procedures and variances from water quality standards.

2) Public Water and Sewer Plans, Cross Connections and Drilling Water Wells (ARM 16.20.401 through 16.20.405)

This regulation requires review of engineering reports and plans and specifications for new water supply systems or alterations or extensions of existing systems. It also provides for registration of well drillers and records kept during well drilling.

This regulation also specifies that reports, plans and specifications shall be prepared in accordance with the Recommended Standards for Water Works prepared by the Great Lakes Upper Mississippi Board of State Sanitary Engineers (Ten States Standards). These standards provide guidance on well and pump station design, construction, testing and operation.

The other important law regarding development of groundwater is the Montana Water Law (Title 85, Chapter 2, Parts 1-8 MCA), administered by the Montana Department of Natural Resources and Conservation. This law defines the process of applying for and obtaining a water right. Important provisions of this law are:

1) Application for Permit (85-2-302)

Defines the application process and the DNRC response to the application.

2) Criteria for Issuance of Permit

- A) There are unappropriated waters in the source of supply:
  - 1) at times when the water can be put to the use proposed by the applicant;
  - 2) in the amount the applicant seeks to appropriate; and
  - 3) throughout the period during which the applicant seeks to appropriate, the amount requested is available;
- B) The water rights of a prior appropriator will not be adversely affected;
- C) The proposed means of diversion, construction and operation of the appropriate works are adequate;
- D) The proposed use of water is a beneficial use;
- E) The proposed use will not interfere unreasonably with other planned uses or developments for which a permit has been issued or for which water has been reserved.

3) Certificate of Water Right

Defines the DNRC action to determine if the appropriation is completed and issuance of a Certificate of Water Right.

TIME REQUIREMENTS

The time required to obtain permits for or review of water development projects can be an important factor in selection of a water supply alternative. Regulatory review time is not completely defined in the applicable statutes.

The Public Water Supply rules do not influence the time required to develop a water system but do have requirements that relate to sampling and testing of operational supplies. The rules regarding public water and sewer plans provides a 60-day review period for water system plans and specifications. If the submitted material is not satisfactory, the Department may notify the applicant and request additional information. In such case, an additional 60 days review period is allowed. The Department could again request additional information, if necessary, and again extend the review period. A reasonable estimate for review of a large groundwater project would be 3 to 5 months after detailed plans and specifications have been completed.

The Montana Water Law provides for agency review of water rights application. The Department of Natural Resources and Conservation has no statutory time requirements for review of an application until the Notice of Application is published. Table 2 gives an estimate of time

TABLE 2. ESTIMATED TIMETABLE TO ACQUIRE WATER RIGHTS

Procedure	Estimated Time Required
1) Submit application for interim permit for test well development.	6 to 8 weeks
2) Drill test wells.	3 to 6 weeks
3) Submit Application for Provisional Permit.	
a) goes to public notice	6 to 8 weeks
b) waiting period	2 to 8 weeks
4) If no objections, permit is issued.	3 to 4 weeks
5) If objections arise:	
DNRC will review objections and gives opinion on effect of proposed well.	4 to 10 weeks
6) Hold public hearings	9 to 12 months
7) DNRC issues Proposal for Decision after Hearings	1 to 2 months
a) comment period	4 months
c) DNRC issues Final Order	1 to 3 weeks
Total estimated time for issuance if public hearing is required	15 to 25 months
Estimated time if public hearing is not required	4 to 7 months

required to issue a groundwater right. This time schedule could be concurrent with the time required for the WQB to review water system plans and specifications. Figure 5 is a flow chart of the time expected from project inception to completion.

CHLORINATION

A specific concern in groundwater development is whether water chlorination would be required by the Department of Health and Environmental Sciences. Meetings with the Department of Health and Environmental Sciences Water Quality Bureau (pers. comm., Dan Frazer, June 1984) indicates that a chlorination program will be required for water from wells. The groundwater supply will need to maintain a chlorine residual when mixing of surface and groundwater occurs at the city reservoirs. Groundwater chlorination equipment need only supply enough chlorine to maintain a residual concentration throughout the city supply system. Theoretically, chlorine required for well water should be less than for surface water. However, chlorine demand in dead end mains may result in chlorine residual problems and require higher dosages, in amounts similar to surface water. Chlorination logically would be added at or near the well field collector system.

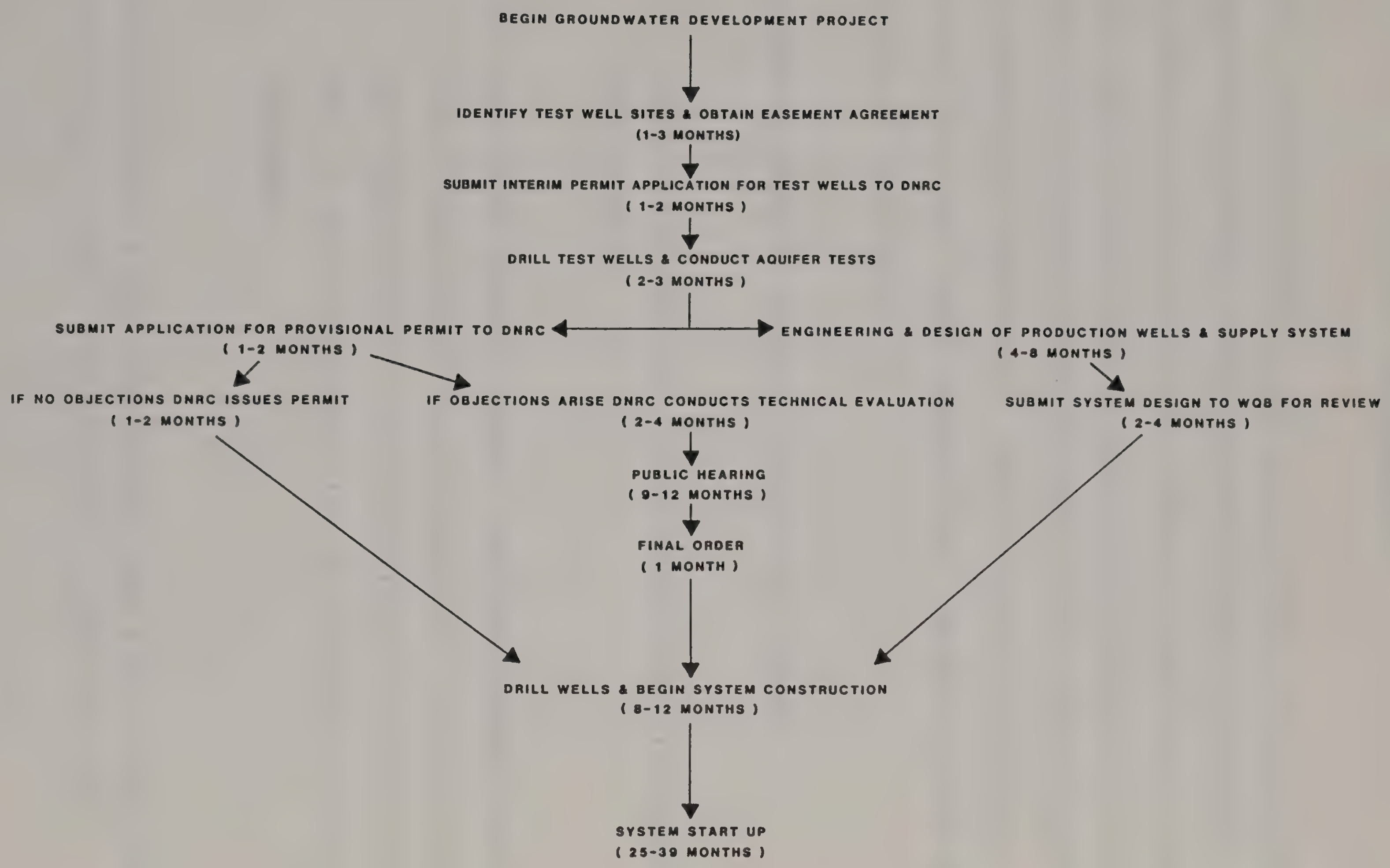

BEGIN GROUNDWATER DEVELOPMENT PROJECT
IDENTIFY TEST WELL SITES & OBTAIN EASEMENT AGREEMENT (1-3 MONTHS)
SUBMIT INTERIM PERMIT APPLICATION FOR TEST WELLS TO DNRC (1-2 MONTHS)
DRILL TEST WELLS & CONDUCT AQUIFER TESTS (2-3 MONTHS)
SUBMIT APPLICATION FOR PROVISIONAL PERMIT TO DNRC (1-2 MONTHS)
ENGINEERING & DESIGN OF PRODUCTION WELLS & SUPPLY SYSTEM (4-8 MONTHS)
IF NO OBJECTIONS DNRC ISSUES PERMIT (1-2 MONTHS)
IF OBJECTIONS ARISE DNRC CONDUCTS TECHNICAL EVALUATION (2-4 MONTHS)
SUBMIT SYSTEM DESIGN TO WQB FOR REVIEW (2-4 MONTHS)
PUBLIC HEARING (9-12 MONTHS)
FINAL ORDER (1 MONTH)
DRILL WELLS & BEGIN SYSTEM CONSTRUCTION (8-12 MONTHS)
SYSTEM START UP (25-39 MONTHS)

FIGURE 5 :

FLOW CHART FOR REGULATORY REVIEW OF GROUNDWATER DEVELOPMENT PROJECT

WATER SYSTEM ANALYSIS

An initial objective of this project was to determine if groundwater development for a municipal supply was feasible and cost-effective in comparison with construction of the proposed 15 MGD Tenmile Creek Treatment Plant. However, on April 26, 1984, the Committee directed Hydrometrics to to evaluate the suitability and cost-effectiveness of various water supply alternatives. These alternatives include use of groundwater, the Missouri River Treatment Plant, the Tenmile System and combinations of these three.

The Groundwater Committee requested the evaluation because:

1) Growth projections for Helena and the Helena Valley have been revised;

2) Costs of the Tenmile Treatment Plant have increased because Chessman Reservoir will require expensive repairs and the water supply line from the proposed Tenmile Treatment Plant site to the city reservoirs may require complete replacement.

Hydrometrics developed a more comprehensive study plan to incorporate the expanded scope of study. Elements of the expanded study are:

1) Using latest population census, water use records, and city/county planning records, estimate the city's water needs for the next twenty years (the life expectancy of a treatment plant or well system);

2) Assess water availability in the Tenmile drainage with and without Chessman and Scott reservoirs including constraints imposed by water rights;

3) Develop a conceptual plan for the proposed Tenmile system using existing 16-inch pipelines (abandoning 24-inch lines) and a pump station;

4) Conduct a system analysis comparing costs of selected water supply options. Options are:

    a) Use of Missouri treatment plant as primary supply source with a groundwater system as a secondary (peaking) supply.

    b) Use of Missouri treatment plant as primary source with Tenmile treatment plant as a peaking supply,

    c) Use of a Tenmile treatment plant as primary source and Missouri as peaking supply,

    d) Use of a groundwater system as primary source and Missouri as peaking supply, and

    e) Combination of Tenmile and groundwater as a primary supply with ground and/or Missouri as a peaking source.

5) Evaluate direct filtration versus conventional filtration systems for a smaller sized Tenmile treatment plant.

6) Evaluate the effects of conservation, additional storage, reduction of peak demands, price elasticity, leak repair, removal of large water users from system and alternative price schecules (off peak rate, inverted price schedule) on system design and operation.

PROJECTED WATER DEMANDS

One of the most significant reasons for reassessment of Helena water needs is the reduction in estimates of Helena's growth in the next 20 years. Recent estimates of City of Helena growth patterns have revised previous estimates from which water demands were derived. The more current estimates do not forsee large increases in Helena's water service area. Original projections for the Helena area that would be served by city water were 58,000 in the year 2000 (Morrison-Maierle-Montgomery, 1978) and 38,500 in the year 2000 (City of Helena, 1981). Present analysis, based on 1980 census data, estimates service popula-

tion will be about 31,600 in 2007 (Appendix 2). Earlier studies predicted large growth in the area north of Custer Avenue. However, growth in this area has been limited by flood plain restrictions along Tenmile Creek. However, higher growth is expected in the area south and east of Helena. This difference in projected growth pattern has significance because of the additional water that will be required from the Malben-Woolston zone to service southeast Helena.

Projected water demands, using the updated population estimates are in Table 3 and Figure 6. Peak demand in the year 2007 for the area to be serviced by the City of Helena water supply system is 20.1 MGD. Total yearly volume is 2222 MG (6.1 MGD) in 1987 and increases about 0.85 percent per year to 2633 MG (7.2 MGD) in 2007. The projected demands do not include the Hale/Eureka zone. This system is capable of meeting projected water demands for its service area through the year 2007 and, consequently, was not included in the analysis. Some water from the Hale/Eureka zone is available for use in the Malben-Woolston zone. A more detailed description of the Helena distribution system, including the Hale/Eureka zone is in the Systems Description section.

TABLE 3. CITY OF HELENA PROJECTED WATER DEMANDS (Excluding Hale/Eureka System)*

Year	Total Volume Required (MG)	Peak Day Demand (MGD)	Average Day Demand (MGD)
1987	2222	17.4	6.1
1992	2316	18.0	6.4
1997	2416	19.4	6.6
2007	2633	20.1	7.2

* Hale/Eureka system is excluded because it will supply projected demands for its service area through 2007.

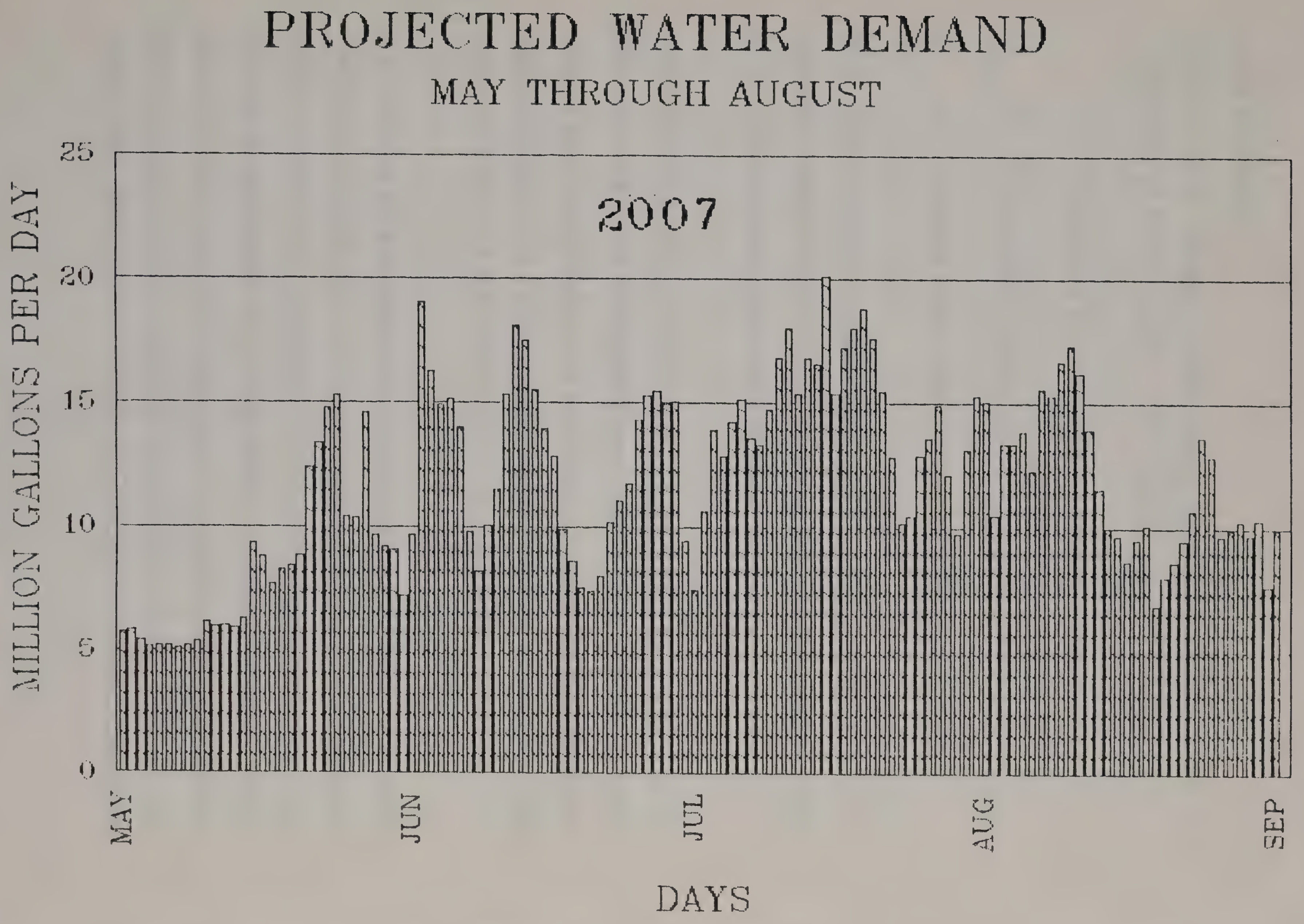


FIGURE 6. YEAR 2007 PROJECTED WATER DEMAND - MALBEN-WOOLSTON SYSTEM

WATER AVAILABILITY

Projected water demands for the City of Helena can feasibly be met by a combination of three sources. These sources are:

1) The existing Missouri River Treatment Plant,
2) A groundwater supply, and
3) A Tenmile Creek surface water treatment plant.

None of the sources appears to be capable of supplying the entire projected demand independently. However, two sources together should be sufficient to meet the projected peak.

Availability of water from the Missouri River is limited by the physical size of the treatment plant, supply lines and the agreement between the City of Helena and the Bureau of Reclamation. The present feasible limit is 9.5 MGD without the addition of an influent pump station and about 12 MGD without plant reconstruction.

Availability of groundwater, as previously discussed, is probably limited to a central or east valley location. In addition, groundwater rights of other users, primarily irrigators, may place severe constraints on development of a large volume groundwater system. Tenmile Creek also has a number of limitations on water availability. Although Tenmile Creek yields an estimated 4249 million gallons per year near Rimini, only about one-half of this is available for Helena's municipal

water supply needs. This is because a large portion of the recorded runoff comes during the spring snowmelt before the peak use season and because a large volume of water is appropriated for other uses during summer low flows.

The City of Helena possesses the first and second water rights on Tenmile Creek for 550 miners inches or 8.9 MGD. In addition, the City also possesses the right to divert and store excess (surplus) water. However, it is unclear what the surplus water availability is because of a lack of sufficient streamflow data.

Tenmile Creek drainage hydrology and water rights are described by Morrison-Maierle-Montgomery in the Water System Improvement Program and Master Plan for the City of Helena (April 1978). As noted in the plan, two U. S. Geological stream gaging stations are located on the creek: one 500 feet upstream of Moose Creek and 2.5 miles north of Rimini and the second station near the Broadwater Hotel, 1.5 miles west of Helena. The Broadwater station potentially provides a means of estimating surplus water availability for use by the city. If surplus water over and above that required by irrigation is available above the Broadwater station, the City can divert or store surplus water. If surplus water is not available, the City cannot store and divert water in excess of its first priority right of 9 million gallons per day (MGD).

As stated by Morrison-Maierle-Montgomery, actual surplus water availability is difficult to determine because:

1) Irrigation diversion data and records, prior to 1966 were difficult to interpret.

2) Not all water diverted for irrigation is consumed. A portion of the diverted water can be expected to return to Tenmile Creek.

3) Since Walker Creek is downstream of the Rimini gaging station, and is ungaged, the estimate of the water it supplies cannot be reliability determined.

Because additional measurements of streamflows and irrigation flows have not been implemented since the Morrison-Maierle-Montgomery (1978) study, it is the best estimate of streamflow and storage availability for the Tenmile system. No further level of detail can be justified. Using data developed for the report, water availability and storage requirements for an 11 MGD treatment plant on Tenmile Creek were calculated (Table 4).

TABLE 4. TEN MILE CREEK WATER AVAILABILITY AND DEMAND FOR AN 11 MGD TREATMENT PLANT

NORMAL YEAR

Month	1987* Projected Demand	Streamflow Available for Diversion	Storage Required	2007 Projected Demand	Streamflow Available for Diversion	Storage** Required
August	287	215	72	314	215	99
September	153	153	0	187	187	0
October	111	111	0	135	131	4
November	94	94	0	114	114	0
December	94	94	0	115	101	14
January	86	86	0	87	87	0
February	78	78	0	78	78	0
March	93	92	1	93	92	1
April	127	127	0	153	153	0
May	200	200	0	223	223	0
June	289	270**	19	308	270**	38
July	327	270**	57	334	270**	64
TOTAL	1,940	1,790	150	2,140	1,921	219

CITY OF HELENA PROJECTED WATER DEMANDS - DRY YEAR

Month	1987* Projected Demand	Streamflow Available for Diversion	Storage Required	2007 Projected Demand	Streamflow Available for Diversion	Storage Required
August	287	208	79	314	208	106
September	153	153	0	187	175	12
October	111	62	49	135	62	73
November	94	57	37	114	57	57
December	94	32	62	115	32	83
January	86	39	47	87	39	48
February	78	32	46	78	32	46
March	93	42	51	93	42	51
April	127	127	0	153	153	0
May	200	200	0	223	223	0
June	289	270**	19	308	270**	38
July	327	270**	57	334	270**	64
TOTAL	1,940	1,492	448	2,140	1,563	577

* Demand required from an 11 MGD peak capacity plant.
** Diversion limited by 9 MGD water right.

Table 4 shows that if the peak capacity of a 11 MGD plant is utilized during a dry year in 2007, at least 577 MG of storage are needed. This would use the entire capacity of Scott Reservoir (194 MG) and about two-thirds of the capacity of Chessman Reservoir (555 MG). During a normal year, Scott Reservoir and the normal streamflow could feasibly supply the City's water needs.

STORAGE AND FIRE PROTECTION REQUIREMENTS

Storage and its effects on fire protection is important when considering improvements to the Helena water system. Storage is important because it provides fire flows even during a power outage. The ability of a water supply system to provide fire protection is rated by the Insurance Services Office on a scale of one to ten, one being the best system and ten being the worst. The adequacy and reliability of the source and storage facilities to supply normal domestic demand and concurrent fire flows during power outages account for approximately 40% of the rating. A gravity supply system normally would be rated higher than a pumped supply unless the pumped supply is equipped with either standby power or additional storage. Helena was graded in 1977 as Class 5, which is higher than other Montana cities. The City was penalized heavily for inadequacy of its sources and storage facilites (Insurance Services Office, pers. comm. July 17, 1984) Consequently, adding storage to the system should be considered when improvements are made. Both the proposed Tenmile and the groundwater system would add six million gallons of storage. However, the groundwater system would add 6 MG of in-town storage would the

Tenmile storage would be at the treatment plant. Maximum flow without power for the Tenmile storage facility would be only 6 MGD. This may limit its usefulness.

SYSTEMS DESCRIPTION

The description of the City of Helena water system and proposed improvements is divided into five main areas:

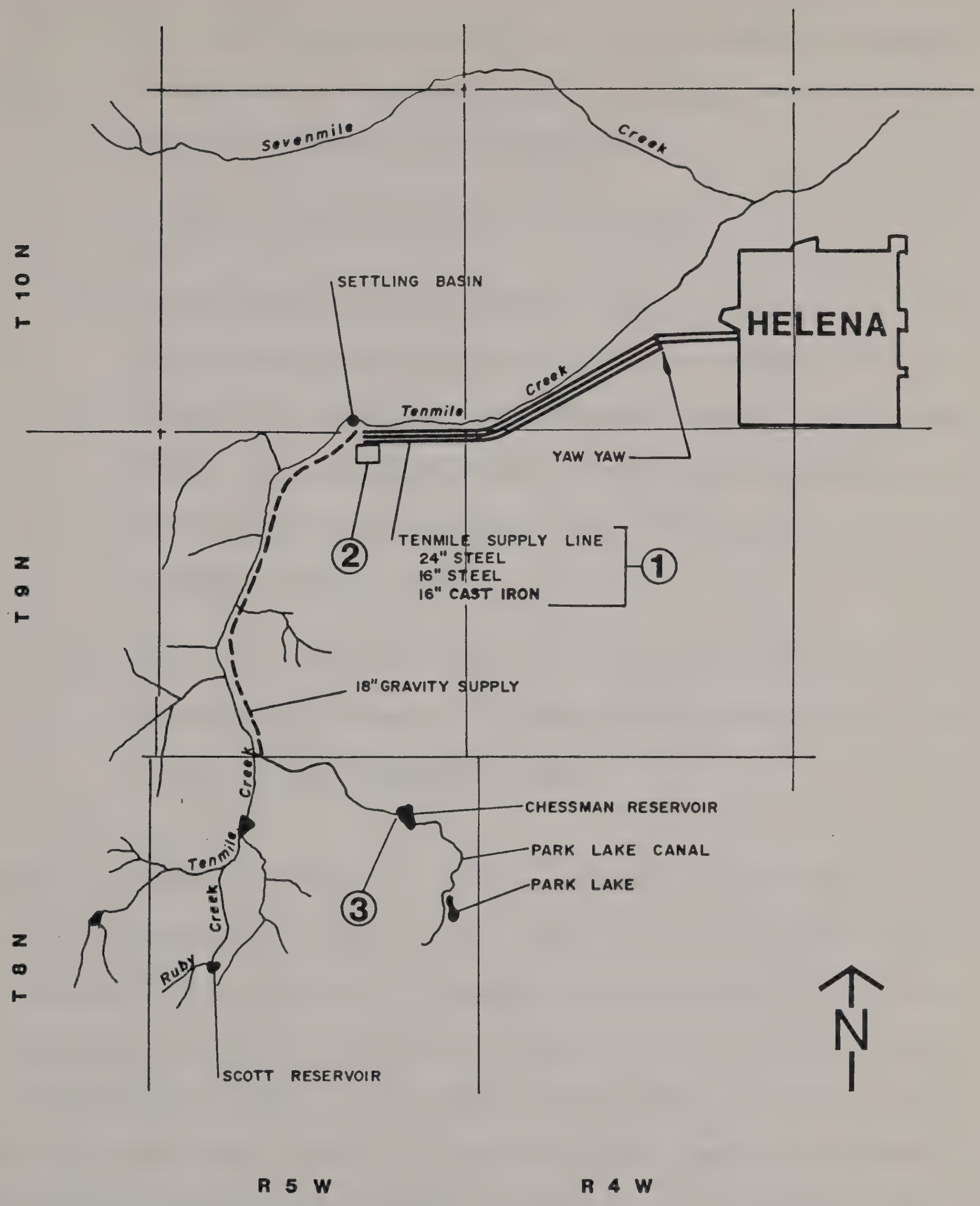
1) Existing Tenmile surface water supply system,
2) Existing Missouri River Treatment Plant and supply system,
3) Helena area distribution system,
4) A proposed groundwater supply system, and
5) Proposed Tenmile surface water improvements.

An understanding of the three main supply systems in addition to a general knowledge of the city distribution system is needed to determine which supply options are most feasible.

Tenmile Surface Water Supply System

The present Tenmile System consists of the following major components (Morrison-Maierle-Montgomery, 1978), (Figure 7):

1) Chessman Reservoir (550 million gallons (MG) storage);
2) Scott Reservoir (194 MG storage);



PROPOSED IMPROVEMENTS

① REPLACE EXISTING LINES WITH 30" LINE
② CONSTRUCT WATER TREATMENT PLANT AT THE SETTLING BASIN
③ REPAIR CHESSMAN RESERVOIR DAM

FIGURE 7

EXISTING TENMILE SURFACE WATER SYSTEM AND PROPOSED SYSTEM IMPROVEMENTS

3) An 18-inch pipeline parallel to Tenmile Creek that extends from Rimini to the settling and surge pond near the intersection of Highway 12 and Rimini Road;

4) A settling and surge pond (6 MG storage)

5) Three supply lines (one 24-inch steel, a 16-inch cast iron and a 16-inch steel) that extend from the settling and surge pond to Yaw-Yaw near the Broadwater Health Spa (27,700 feet). Presently, the 24-inch line is in poor condition and is estimated to leak about 1 to 1.5 MGD (pers. comm. Lyle Griffiths, May 15, 1984).

6) Two lines (a 24-inch steel and a 14-inch cast iron) that extend from Yaw-Yaw to Williams Street (7,000 feet) and the Malben-Woolston reservoir system.

Typical operating procedure is to utilize streamflow from Tenmile Creek and its tributaries in the winter and early spring months until downstream irrigation begins. Headgates at the various intakes along the 18-inch supply pipeline are controlled to minimize turbidity. When irrigation begins water is drawn from Scott Reservoir. Normally, Scott provides water until the end of July or the first few weeks in August. At this time, water from Chessman is used until the irrigation season is over and streamflows increase enough to supply the demand. Scott and Chessman are filled during the spring runoff.

Peak capacity of the present system is about 9 million gallons per day (pers. comm. C. Dickertt, July 16, 1984). The limiting factor is the supply lines between the settling/surge pond and the city. Settling, rough screening and chlorination are done at the settling and surge pond and are the only treatments given the raw water. The settling pond is reportedly short circuiting and presently only reduces turbidities by about 0.5 NTU (pers. comm. Lyle Griffiths, May 12, 1984).

The capacity of the Tenmile system varies with pipeline size and storage facilities utilized. The existing system can supply about 9 MGD using the existing two 16-inch and the 24-inch pipeline (C. Dickertt, pers. comm. July 16,1984). Because the capacity of the Tenmile system to satisfy the future water demands is impacted by the capabilities of the transmission mains, an analysis of the mains is important. A report by CH2M Hill (1983) in the environmental impact statement for the Helena West Highway project concluded the 16inch diameter cast iron main has a remaining life of 75 years; the 16inch steel main has a remaining pipe life under worst corrosion conditions of 20 years. If within five years the internal corrosion rate is minimized by treating the water at Tenmile to make it noncorrosive, the life of the pipe can be extended to 30 or 40 years. If cathodic protection is applied to the pipe and if the water is treated, the pipe life could be extended to that of the cast iron pipe (75 years). The projected usable life of the existing 24-inch line from the settling basin to the juncture with the 16-inch mains at Yaw Yaw was less than

TABLE 5. TENMILE TRANSMISSION SYSTEM

Pipe	Length (ft)
(Settling basin to Yaw Yaw)	
16 inch cast iron	27,720
16 inch steel	27,720
(Yaw Yaw to Woolston)	
14 inch cast iron (reduces to 12 inch at Cannon St.)	27,318
24 inch steel (reduces to 20 inch at LaGrande and Grant Sts.)	27,318

Elevations	FT, MSL*
Settling Basin	4,420
Yaw Yaw	4,034
Woolston, Overflow	4,307

* Mean Sea Level

five years. The remainder of the 24-inch main is in acceptable condition.

Elements of the transmission system exclusive of the 24-inch main from the settling basin to Yaw Yaw are summarized in Table 5. The pipe configuration taken as a whole from the settling basin to Woolston Reservoir would be equivalent to a single 23-inch diameter pipe. Taken as two separate pipes in series corresponding to a pipe from the settling basin to Yaw Yaw and another pipe from Yaw Yaw to Woolston, the two 16-inch pipes in parallel are equivalent to a single 21-inch main.

Investigations conducted by Hunt (1970) estimated a hydraulic fiction coefficient Hazen-Williams "C" factor of 110 for water mains in the Helena water system. Using the Hazen-Williams "C", capacity of the Ten Mile Transmission system to deliver water to the City of Helena under gravity conditions exclusive of the 24-inch main from the settling basin to Yaw Yaw is computed to be 6 million gallons per day.

Missouri River Treatment Plant

The existing facilities of the Missouri River Treatment Plant (Figure 8) are:

1) Regulating reservoir water supply seven miles east of Helena;

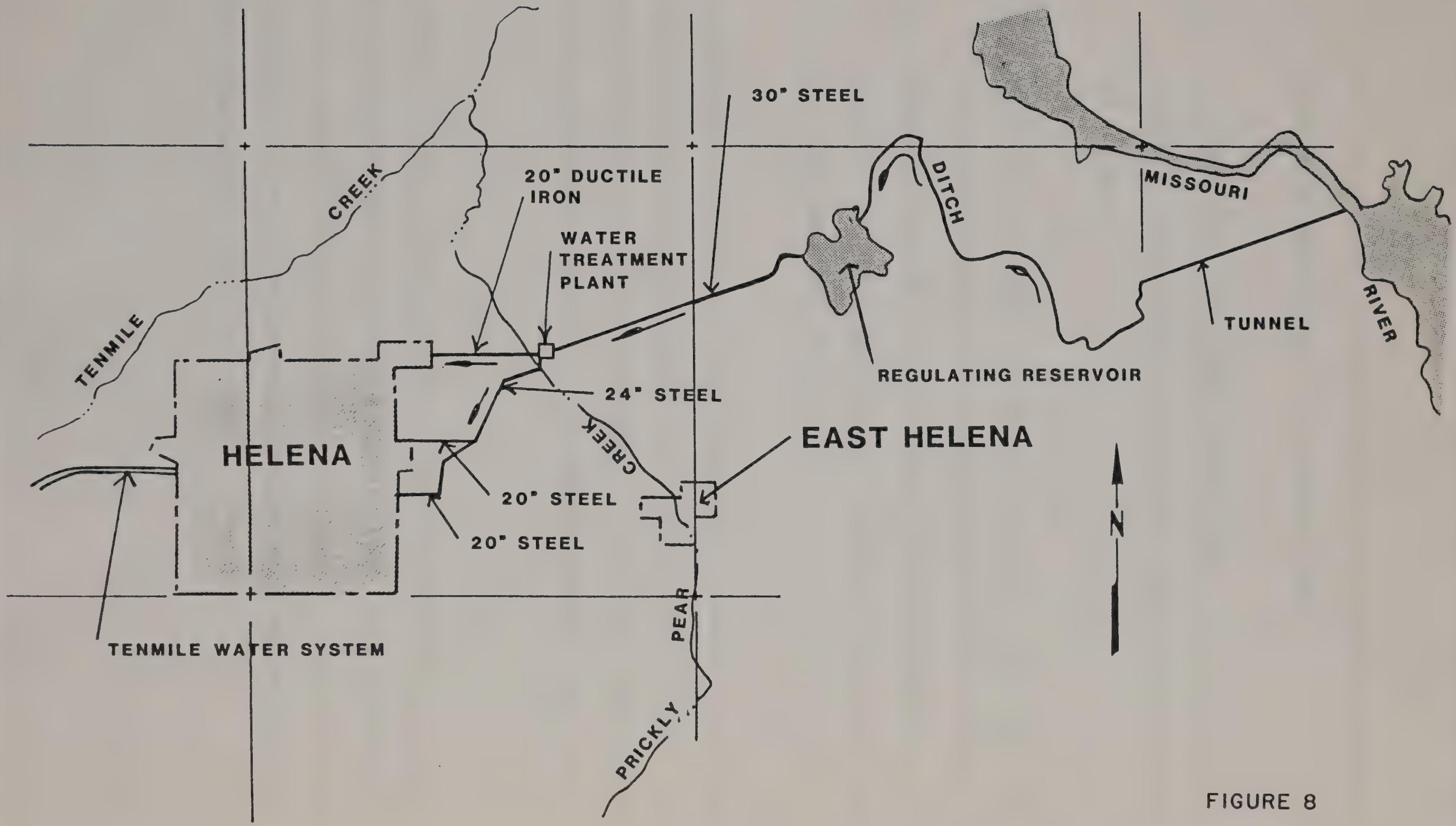


FIGURE 8

EXISTING MISSOURI RIVER SURFACE WATER SYSTEM

2) Six miles of 30-inch gravity pipeline extending from the regulating reservoir to the treatment plant;

3) A 12 MGD total capacity (9.5 MGD nominal) conventional treatment plant located on Canyon Ferry Road two miles east of Helena.

4) Upper zone and lower zone 20-inch pipelines. The upper zone line extends from the treatment plant to Malben-Woolston reservoir system. The lower zone line serves Helena area north of the Burlington Northern Railroad tracks excluding the city industrial park.

The regulating reservoir is a multipurpose impoundment used for irrigation and the Helena municipal water supply. The reservoir is managed by the Bureau of Land Management. Currently, the City of Helena has a contract to purchase up to 5680 acre-feet of water annually.

The 30-inch gravity pipeline from the regulating reservoir extends along Canyon Ferry Road and is about six miles long. Flow capacity of the line is about 9.5 MGD when the regulating reservoir is at low stage which normally occurs in the summer. A booster pump station would be required increase the capacity to 12 MGD.

The water treatment plant facility located on Canyon Ferry Road has a design capacity of 12 MGD. However, the present capacity of the plant is 9.5 MGD because of the limited capacity of the incoming gravity pipeline. The maximum projected demand (peak day year 2007) in the low zone is about 3.3 MGD and maximum volume that can be pumped to the upper zone is 5.8 MGD. The theoretical design capacity of the upper zone pipeline is greater than 6 MGD but severe surge problems have hindered higher pumping rates.

City Distribution System

The city distribution system ranges in elevation from 3800 to 4500 feet and is divided into four pressure zones (Figure 9):

1) Upper Malben-Woolston
2) Lower Malben-Woolston
3) Hale/Eureka
4) Winne

The following is a general description of each zone and its importance in the projected water improvement program. A detailed description of the system is in the 1978 Water System Improvement Program and Master Plan (Morrison-Maierle-Montgomery, 1978).

Malben-Woolston Zones

The Upper and Lower Malben-Woolston zones comprize about 85 to 95 percent of the city's water distribution system. Elevation varies from

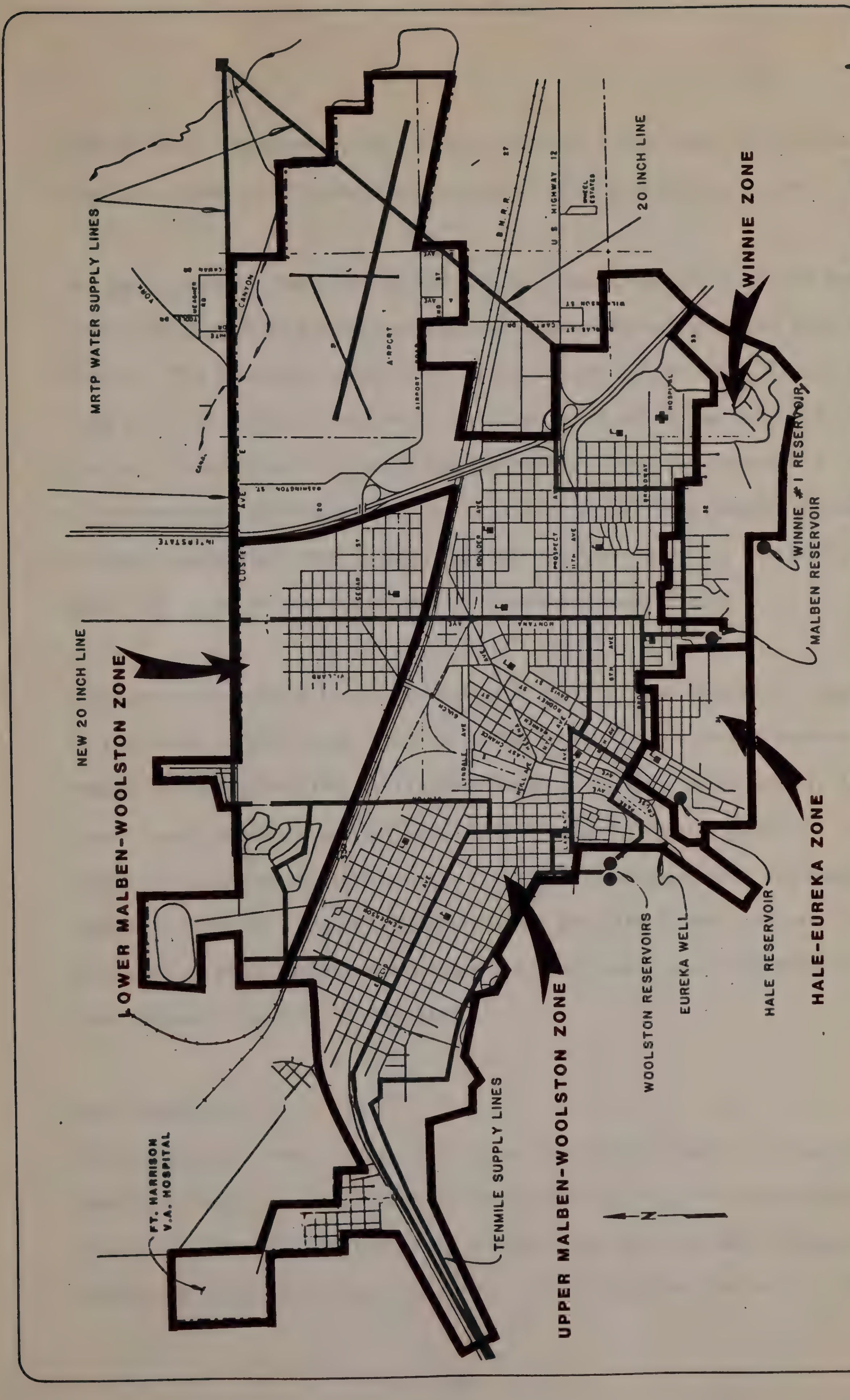
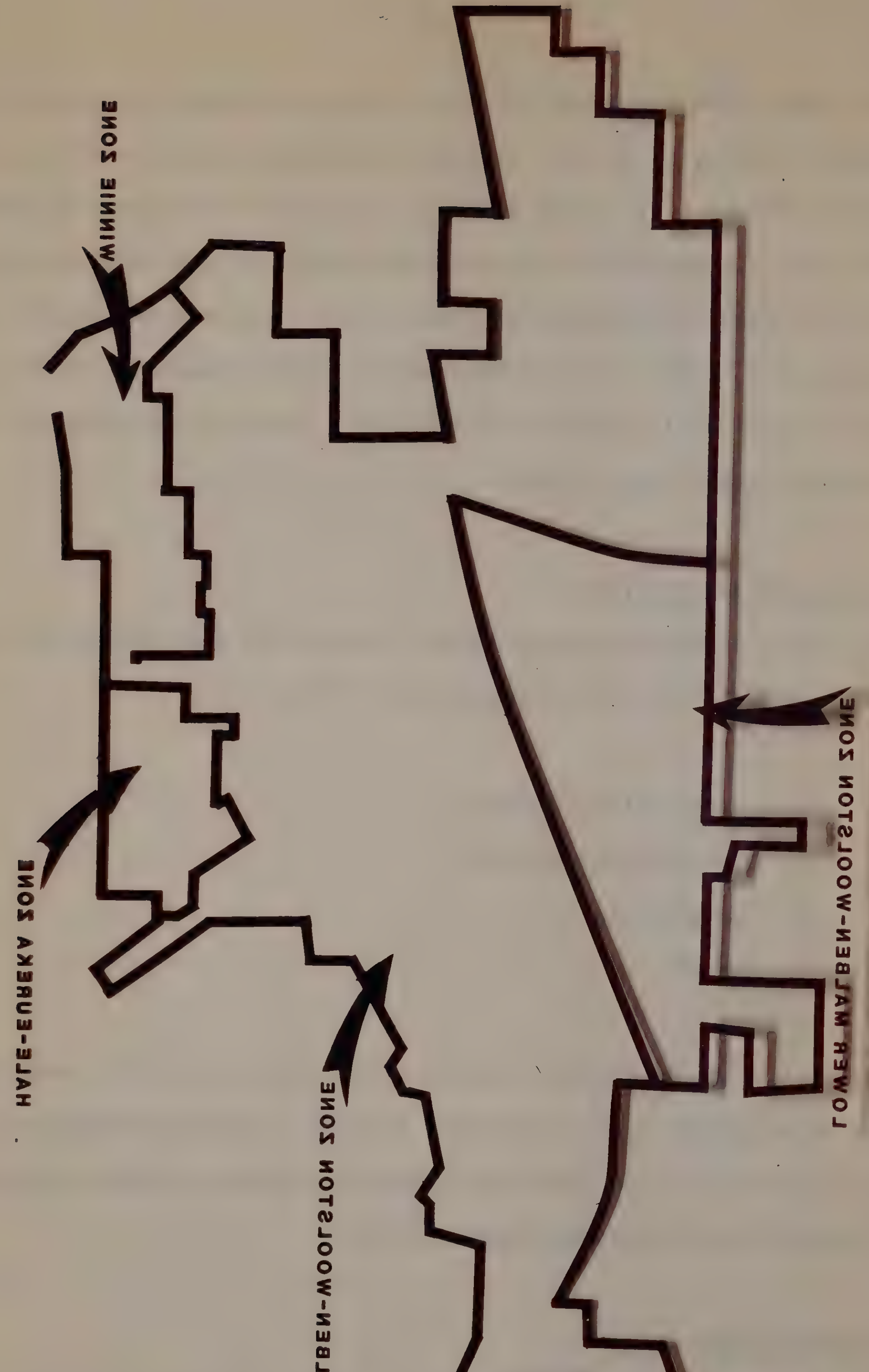


FIGURE 9: CITY OF HELENA WATER DISTRIBUTION SYSTEM


MINNIE ZONE
HALE-EUREKA ZONE
UPPER WALSEN-WOOLSTON ZONE
LOWER WALSEN-WOOLSTON ZONE

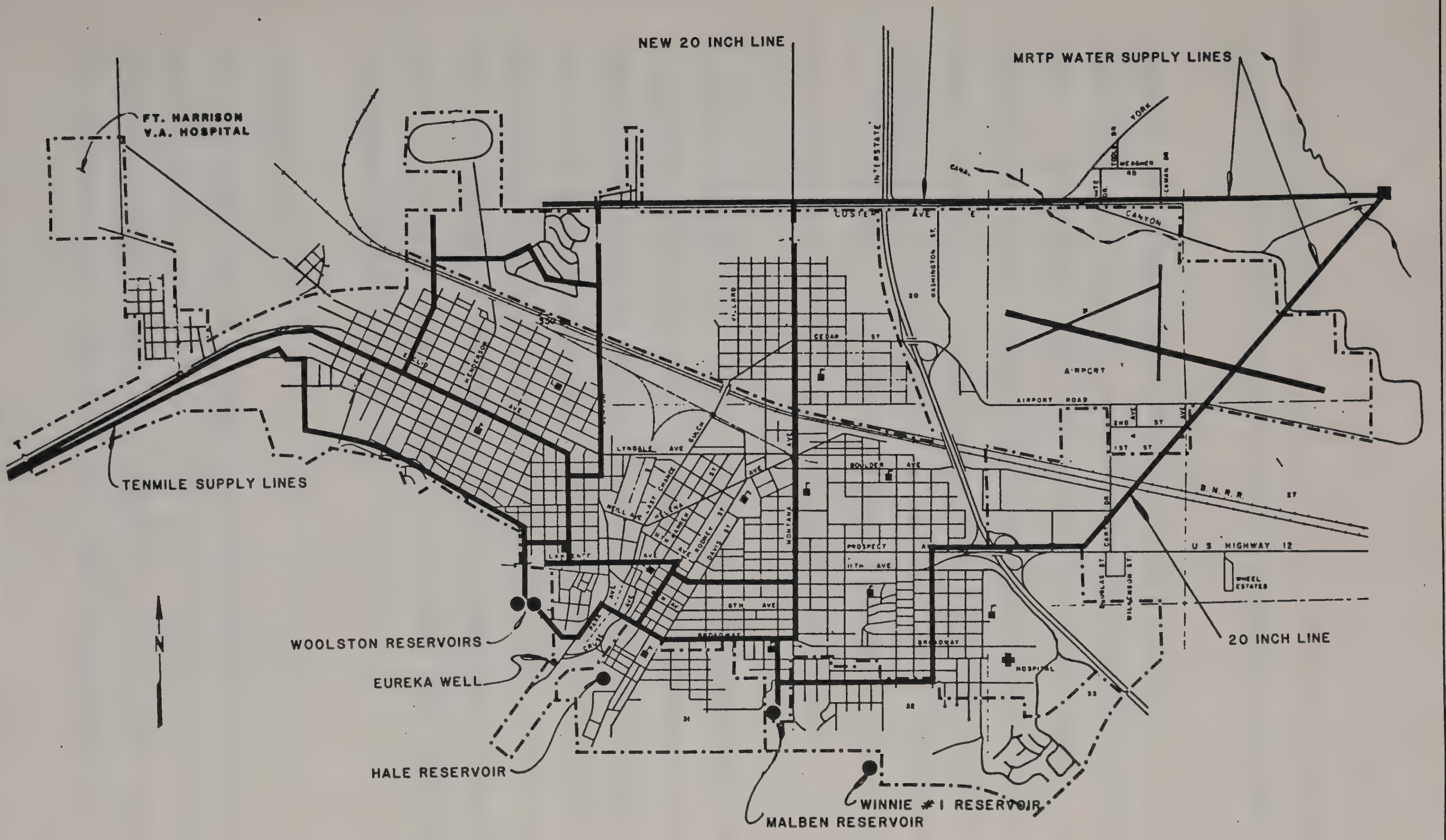


FIGURE 9 : CITY OF HELENA WATER DISTRIBUTION SYSTEM

3820 to 4275. Because of the large elevation differences, the Malben-Woolston system is divided into the upper and lower pressure zones.

The upper zone is supplied by the two Woolston reservoirs at the base of Mt. Helena and by the Malben reservoir near the end of South Montana Street. The Woolston reservoirs are supplied by the Tenmile supply line while the Malben reservoir receives most of its water from the Missouri River Plant. A cross-town pipeline links the reservoirs and allows exchange of water when one or the other of the supply systems are not operating. The upper zone serves the majority of the city above and south of the Burlington Northern Railroad tracks.

The lower zone serves the city below and north of the BN tracks. Water is supplied to the lower zone from the upper zone through pressure reducer valves along the Burlington Northern tracks. Alternately, the lower zone receives water from the Missouri River Plant via the recently constructed 20-inch supply pipeline along Custer and Benton Avenues (Figure 9). During periods of low use, the lower zone can also be supplied with groundwater from a 0.8 MGD well near the Missouri Plant through the 20-inch pipeline.

Hale/Eureka Zone

The Hale/Eureka zone is located above the Malben-Woolston zone and comprizes less than 5 percent of the existing distribution network (Figure 8). The zone is served by gravity flow from the Hale Reservoir (Elevation 4370) and the Eureka well (infiltration gallery). The

Hale/Eureka system is separated from the upper Malben-Woolston zone by valves along Broadway Street. Because of limited growth potential, the supply from the zone is expected to exceed the demands in the design except during peak periods. Consequently, a small surplus will be used to supplement the upper Malben-Woolston zone when available.

Winne Zone

The Winne zone serves about 7 to 10 percent of the distribution system and ranges in elevation from 4477 at the Winne tank south of Virginia Dale Street to 4050 near Beltview and Saddle Drives. All of the water to the Winne zone must be pumped from the Upper Malben-Woolston zone. Consequently, the zone is essentially an extension of the Malben-Woolston zone. The Winne zone is experiencing rapid growth which is expected to continue in the next 20 years. Much of the projected demand in the future comes from this area.

Helena Valley Groundwater System

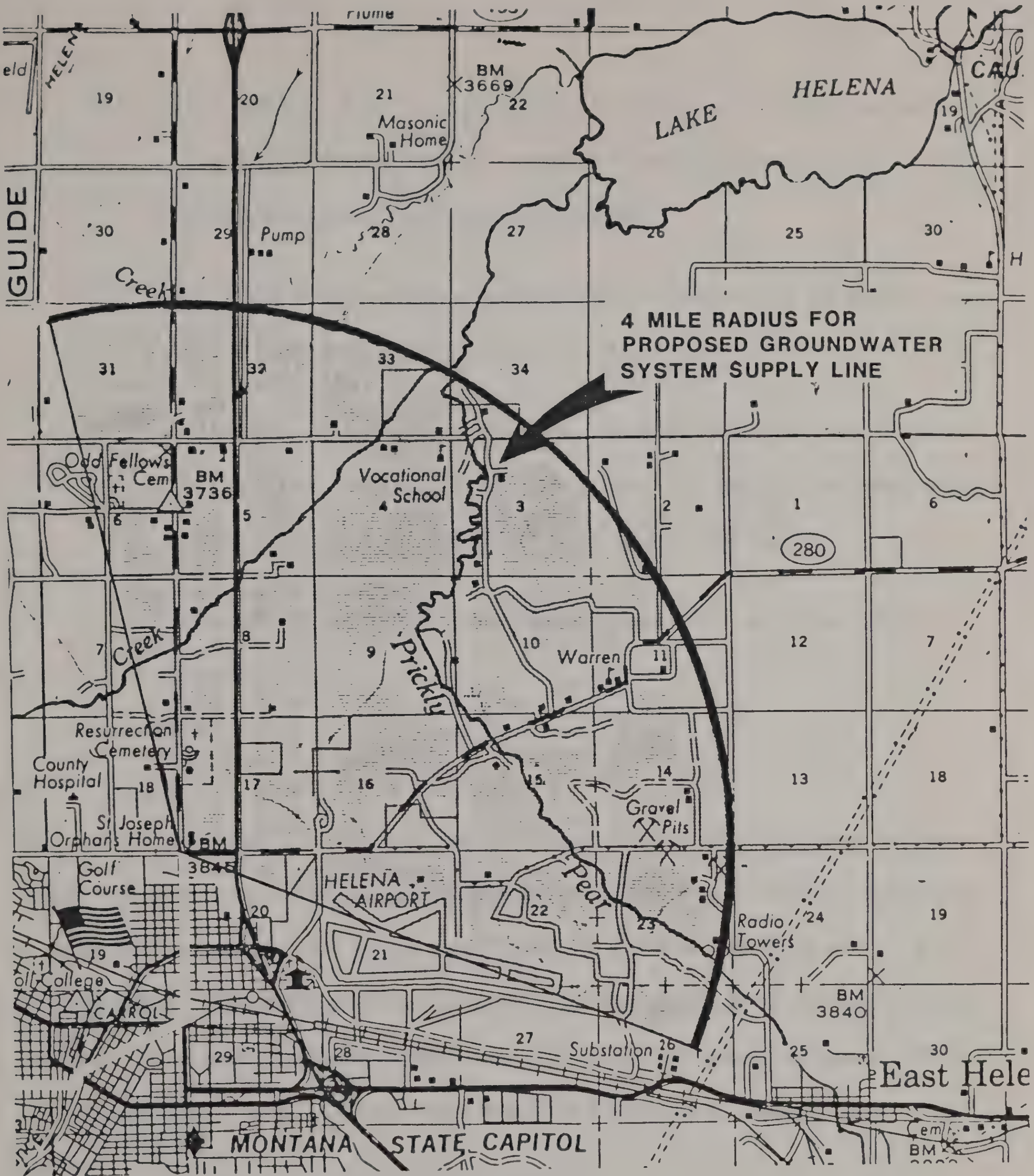
A hypothetical Helena Valley groundwater supply would extend from a point in the Central or East Valley area to the Malben-Woolston Reservoir system (Figure 10).

The supply system will consist of the following major components:

1) Well field of 6-8 wells;

2) Collector system;

3) Chlorination system;



4 MILE RADIUS FOR PROPOSED GROUNDWATER SYSTEM SUPPLY LINE

SUPPLY LINE THROUGH TOWN
TO WOOLSTON RESERVOIR

FIGURE 10

PROPOSED CENTRAL OR EAST
VALLEY GROUNDWATER SUPPLY LINE

4) 24-inch (11 MGD) or 30-inch (15 MGD) ductile iron supply line (21,200 feet) that extends from a point in the Helena Valley to Custer and Montana Avenue.

5) Optional high service pump station (required if wells are not designed to supply total lift).

6) A 24-inch (11 MGD) or 30-inch (15 MGD) ductile iron distribution line from Montana and Custer to the Malben-Woolston Reservoirs with feeder line taps along the route.

7) An additional 6 MG storage reservoir at the Woolston reservoir.

Well Field

The exact location of a potential the well field is not known at this time. However, existing hydrolgeologic data indicates that a suitable source of groundwater can be developed in either the Central or East Valley area. The East Valley location is the most promising location because it is more sparsely populated which may allow development of an extensive well field without interferring with water rights of present users.

For purposes of initial cost comparisons (15 MGD supply size), it was assumed that a suitable groundwater source could be developed and would be located within a distance of four miles from the Custer and Montana Avenue intersection. This distance encompasses an area extending eastward to the intersection of Canyon Ferry Road and Wylie Drive,

northeastward to a point slightly beyond the Mountain View School for Girls and northward to a point one mile beyond the intersection of Montana Avenue and Sierra Drive (Figure 10).

A typical well field arrangement would consist of two sets of four wells. Wells will be approximately 600 feet apart and 150 feet deep. Estimated pumping water level is 100 feet below ground surface. Each well is estimated to be capable of yielding about 2000 gpm.

Collector System and Chlorination Equipment

Each well would be manifolded into the main supply line. Wells would be equipped with telemetry equipment and would cycle to meet demand required at the city reservoir system. Initially, only four to six wells would be drilled, developed and put into service. As system requirements increased, additional wells would be added to the system.

Chlorination of the groundwater supply would be required to maintain a chlorine residual when mixing of surface and groundwater occurs at the city reservoirs. However, the chlorination equipment required of the groundwater system need only supply enough chlorine to maintain a residual concentration. The one-hour contact hour time normally required of surface water systems will not be required. Chlorination would be added at or near the well field collector system.

Main Supply Line

The main supply line would consist of a 24-inch (11 MGD) or 30-inch (15 MGD) ductile iron pipe extending from the well field collector system to the City of Helena distribution system at the intersection of Custer and Montana Avenues. Approximate length is four miles, or 21,200 feet. Costs for the pipeline include digging, laying and backfilling.

Optional High Service Pump Station

The large elevation difference between the well pumping level and the reservoir elevation may require an intermediate high-lift pump station be installed in the system. Estimated elevation difference is about 700 to 750 feet. To minimize power transmission costs, the pump station would be located near the 69 kilovolt power line than extends along Custer Avenue (Figure 10). A sub-station must be constructed because of the large power requirements of the pump station (MPC, pers. comm., March 12, 1984).

If wells can be located within a short distance of the city limits, the pump station may be eliminated. Water would then be pumped directly from the well to the reservoirs. This would be feasible because of reduced pumping head and a shorter pipeline which would reduce the possibility of surging.

Connection to City Distribution System

The City of Helena's present distribution system is pressurized by the elevation head supplied by the Malben-Woolston reservoirs. Consequent-

ly, the reservoirs and large trunk lines are located at the upper portions of the city. All water in the high pressure system, including water from the present Missouri River Treatment Plant, passes through one of these reservoirs. A groundwater system, therefore, would also supply the major portion of water to these upper locations.

Preliminary in-town alignment for the groundwater supply system pipeline would be along Montana Avenue from Custer to the intersection with Helena Avenue, then along Helena Avenue to Placer Street, and up Placer Street to the 24-inch trunk line that feeds the Woolston Reservoir. The 30-inch line will be tapped by small feeder lines along the route which will allow reduction of its size near the reservoirs.

Proposed Tenmile System Improvements

The City of Helena has agreed to meet drinking water standards by 1987 (Appendix 3). Improvements are proposed for the Tenmile system in three areas.

First, a conventional treatment plant is planned at the settling ponds to control turbidity, taste and odor problems and the potential for bacteriological problems. Turbidity of the present system at times exceeds the Federal Safe Water Drinking Act of five turbidity units. A schematic of the proposed conventional plant is shown on Figure 11. Raw water from Tenmile Creek is mixed with coagulants in a rapid mix chamber and pumped to the floculation/sedimentation basin where the growth of large settable particles occurs. Flow then passes through a

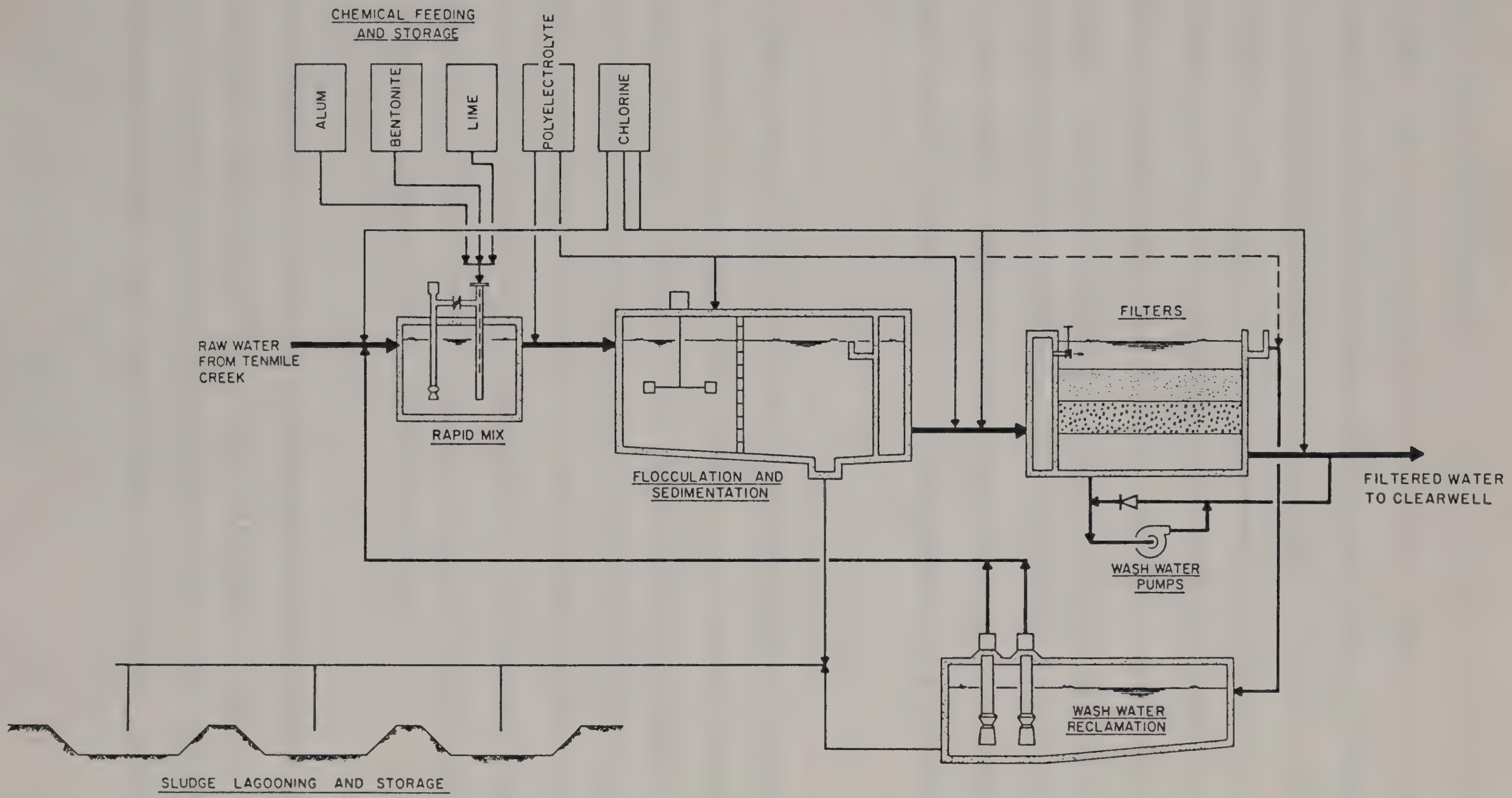

CHEMICAL FEEDING AND STORAGE
ALUM
BENTONITE
LIME
POLYELECTROLYTE
CHLORINE
RAW WATER FROM TENMILE CREEK
RAPID MIX
FLOCCULATION AND SEDIMENTATION
FILTERS
FILTERED WATER TO CLEARWELL
WASH WATER PUMPS
WASH WATER RECLAMATION
SLUDGE LAGOONING AND STORAGE

FIGURE 11

CONVENTIONAL PLANT SCHEMATIC DIAGRAM

SOURCE: MORRISON-MAIERLE, MONTGOMERY, 1978

common wall into the sedimentation basin where particles and floc settle out. The settled water is collected, preconditioned with polyelectrolyte or chlorine and routed to the filters. Filters are gravity-type dual media (anthracite and sand). Filtered water is chlorinated as necessary to provide adequate residual in the city distribution system. The plant would be designed to operate by direct filtration (without the flocculation/sedimentation stage) during much of the year. General conditions that allow use of direct filtration are low turbidity water, absence of taste and odors and low alkalinity. These conditions are expected to occur about 8 months out of the year. The remainder of the year the plant would operate as a conventional plant.

Second, the 24-inch supply line from the settling pond to Yaw-Yaw and along Highway 12 to town will require replacement because of construction along Highway 12. The Montana Highway Department (MHD) may be responsible for a portion of the costs of the replacement. However, at this time, it is unclear what that portion will be. The MHD claims that, because of its poor condition, the line has no useful life or salvage value. For this investigation, it is assumed that the City of Helena will bear complete replacement costs.

A third consideration in the Tenmile improvement is the additional cost of repairing Chessman Reservoir. A dam safety analysis by Morrison-Maierle in 1983 has determined that Chessman Dam does not have an adequate seismic safety factor to be filled to peak capacity (Morrison-

Maierle, 1984). Consequently, either the dam must be repaired or used at reduced capacity. Cost to repair the dam is estimated to be 1.06 million dollars. The reduced capacity at which the reservoir may be operated with an adequate seismic safety factor is not known.

The maximum daily demand required of the Tenmile System is estimated to be 11 million gallons per day in the year 2007. Therefore, either the 24-inch main from the settling basin to Yaw Yaw will have to be replaced or an in-line booster station constructed to maximize the availability of water from the Tenmile System. Cost of pipeline replacement is contained in the 15 MGD cost comparisons and is much more expensive than a booster pump station.

Hydraulic investigations conclude that if an 11 million gallon per day booster station were constructed at Yaw Yaw and the pipeline were kept full and allowed to "float" on the settling basin, the resulting velocity of water in the pipeline would be 7.2 per second. Velocities of seven feet per second are high but are commonly accepted in design practice. The pressure at the intake of the booster station would be 44 pounds per square inch and the discharge pressure would have to be 115 pounds per square inch. The net differential pressure of 71 pounds per square inch requires a 420 horsepower pump assuming an efficiency of 75 percent. Operation of the booster station would only be required when the demand exceeds 6 MGD. Presently, the pipeline capacity is approximately 3.6 MGD. The reason the pipeline does not flow at the theoretical capacity of 6 MGD is not known.

COST COMPARISON AND ALTERNATE OPTIONS

COST ANALYSIS ASSUMPTIONS

The following assumptions were used in developing costs for both the Tenmile Creek surface supply, the Helena Valley groundwater systems and the Missouri River Treatment Plant (MRTP).

1) Power costs follow Montana Power Company rate schedule estimates as submitted to the Montana Public Service Commission (April 1983).

2) Interest rate for municipal bonds to finance capital cost (except MRTP) is 10 percent annually for a 15 year period. MRTP interest rate is 9.2 percent for 20 years which began 1981.

3) Design life of pipelines is 40 years; design life of treatment plants, pump stations and wells is 20 years.

4) Cost to acquire water rights, access to property and right-of-way easements for groundwater system is estimated at $250,000. This could increase substantially if legal difficulties arise.

6) Cost to determine and improve the capacity of the existing Tenmile 16-inch pipelines to its design of 6 MGD is minimal and can be achieved by maintenance funds.

A few other factors should also be considered. One is that there are still a number of unknowns in the groundwater option including whether sufficient good quality water is readily available at a reasonable distance from the city limits and what is the cost would be to obtain right-of-way easements to build a pipeline.

Annual costs for power, maintenance and chemicals were adjusted for an inflation of 4.8 percent per year. This value is the approximate prediction made by the Montana Power Company in their April 1983 rate increase request. This value appears to be a reasonable estimate of future inflation given the uncertainty of economic predictions. Although, not strictly true, adjusted or equivalent annual costs can be thought of as an average between 1987 and 2007 costs, including operation, maintenance, capital cost and debt service.

15 MGD COST COMPARISONS

At the March 15, 1984, Groundwater Committee meeting, Hydrometrics and Morrison-Maierle were directed to develop costs for a 15 MGD capacity groundwater system and to update costs of the proposed 15 MGD Tenmile surface water treatment plant. These were to be compared to determine if a groundwater supply is a feasible, cost-effective alternative.

Costs for a 15 MGD capacity Central or East Valley groundwater supply and updated costs for a proposed 15 MGD Tenmile surface water supply are shown on Tables 6 and 7. Detailed costs are in Appendix 4. Comparison of these costs indicate that over the long-term, the options

TABLE 6.

COST ESTIMATE FOR CITY OF HELENA GROUNDWATER SUPPLY - 15 MGD
CENTRAL OR EAST VALLEY LOCATION

DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	TOTAL COST
SITE INVESTIGATION				
drill test wells, aquifer test, sample	Each	$10,000.00	5	$50,000.00
obtain water rights & easements	lump sum	$250,000.00	1	$250,000.00
			SUB-TOTAL	$300,000.00
DRILL HI-CAPACITY WELLS				
incl drilling, development and misc	Each	$40,000.00	6	$240,000.00
install pumps w/controls	Each	$75,000.00	6	$450,000.00
			SUB-TOTAL	$690,000.00
CONSTRUCT WELL MANIFOLD SYST				
12 inch pipe	L.F.	$70.00	1200	$84,000.00
16 inch pipe	L.F.	$80.00	1200	$96,000.00
20 inch pipe	L.F.	$90.00	1200	$108,000.00
24 inch pipe	L.F.	$100.00	1200	$120,000.00
				$408,000.00
valves & fittings (25%)	total	$102,000.00	1	$102,000.00
			SUB-TOTAL	$510,000.00
CHLORINATION EQUIPMENT	lump sum	$30,000.00	1	$30,000.00
			SUB-TOTAL	$30,000.00
CONSTRUCT PUMP STATION				
Pumphouse w/ wetwell	Each	$50,000.00	1	$50,000.00
Turbine pumps	Each	$50,000.00	6	$300,000.00
Pump controls	Each	$50,000.00	6	$300,000.00
telemetry equipment	lump sum	$100,000.00	1	$100,000.00
				$750,000.00
valves & fittings (25%)	total	$187,500.00	1	$187,500.00
			SUB-TOTAL	$937,500.00
CONSTRUCT PIPELINE				
30 inch pipeline	feet	$115.00	21120	$2,428,800.00
36 inch steel casing	feet	$325.00	175	$56,875.00
				$2,485,675.00
valves & fittings (15%)	lump sum	$372,851.25	1	$372,851.25
			SUB-TOTAL	$2,858,526.25
			PAGE TOTAL	$5,326,026.25

CITY OF HELENA GROUNDWATER SUPPLY COST ESTIMATE (CONT)

DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	TOTAL COST
			BAL FORWD	$5,326,026.25
6 MG STORAGE FACILITY				
6 mg steel tank w/ foundation & piping	lump sum	1,101,700	1	$1,101,700.00
CITY WATER MAIN SYSTEM				
pavement replacement	S.Y.	$20.00	10719	$214,380.00
trench excavation	C.Y.	$3.04	22841	$69,436.64
30 inch pipeline	L.F.	$110.44	12175	$1,344,607.00
valves & fittings	lump sum	$91,041.40	1	$91,041.40
20 inch pipeline	L.F.	$61.66	2650	$163,399.00
valves & fittings	lump sum	$22,765.48	1	$22,765.48
12 inch pipeline	L.F.	$28.91	140	$4,047.40
valves & fittings	lump sum	$18,329.33	1	$18,329.33
10 inch pipeline	L.F.	$24.87	325	$8,082.75
valves & fittings	lump sum	$1,223.18	1	$1,223.18
			SUB-TOTAL	$1,937,312.18
	ESTIMATED CONSTRUCTION COST			$8,365,038.43
	Contingencies @ 15%			$1,254,755.76
			SUB-TOTAL	$9,619,794.19
	Engineering & Inspection @ 15%			$1,442,969.13
	Legal & Administrative @ 3%			$288,593.83
				$11,351,357.15
	Financing @ 3%			$340,540.71
1984 TOTAL PROJECT COST (ENR 1984 = 4118)				$11,691,897.86
1987 TOTAL PROJECT COST (ENR 1987 = 4204)				$11,936,070.57

TABLE 7.

COST ESTIMATE FOR CITY OF HELENA SURFACE WATER SUPPLY - 15 MGD
TEN MILE CREEK DRAINAGE

DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	1984 TOTAL COST ENR = 4118	1986 TOTAL COST ENR = 4204
CONSTRUCT 15 MGD TREATMENT PLANT	lump sum	$8,066,000.00	1	$8,066,000.00	$8,234,449.73
SUB-TOTAL (INCL CONTINGINCIES, ENGINEERING & LEGAL)				$8,066,000.00	$8,234,449.73
CONSTRUCT 30 INCH PIPELINE					
30 inch pipeline	L.F.	$143.55	34142	$4,900,949.92	$5,003,300.99
42 inch RCP casing, Xing	L.F.	$92.26	400	$36,904.00	$37,674.70
air release valve & man.	each	$3,845.00	3	$11,535.00	$11,775.90
perm. service w/encasemnt	each	$1,922.50	23	$44,217.50	$45,140.93
perm. service wo/encasemnt	each	$538.30	6	$3,229.80	$3,297.25
30 inch butterfly valve	each	$10,509.68	13	$136,625.84	$139,479.12
30 inch blowoff valve	each	$3,588.67	2	$7,177.34	$7,327.23
24 inch connection	each	$5,383.01	2	$10,766.02	$10,990.86
16 inch pipeline	L.F.	$62.78	478	$30,008.84	$30,635.54
16 inch butterfly valve	each	$1,922.49	1	$1,922.49	$1,962.64
16 inch connection	each	$2,691.50	4	$10,766.00	$10,990.84
pavement restoration	S.Y.	$22.43	270	$6,056.10	$6,182.58
SUB-TOTAL (INCL CONTINGINCIES, ENGINEERING & LEGAL)				$5,204,868.75	$5,313,566.84
REPAIR CHESSMAN RESERVOIR	lump sum	$1,006,000.00	1	$1,006,000.00	$1,027,009.23
SUB-TOTAL (INCL CONTINGINCIES, ENGINEERING & LEGAL)				$1,006,000.00	$1,027,009.23
TOTAL PROJECT COST				$14,276,868.75	$14,575,025.80

are about equal economically. The groundwater option would require less initial capital investment than the Tenmile system but would be more expensive to operate on an annual basis because of the higher pumping costs.

Costs of the Tenmile and groundwater 15 MGD systems were presented to the Groundwater Study Committee meeting on April 26, 1984. After reviewing the information, the consensus of the Committee was to continue the investigation but to look at other water supply options before committing to either a groundwater or a Tenmile 15 MGD plant.

ALTERNATE SUPPLY OPTIONS

Following the cost analysis of the Ten Mile and groundwater 15 MGD supply systems, other options were considered using the new projected water demands. In the analysis, the Hale/Eureka system was not included because the system will supply more than its service area through the year 2007. Excess water supplied by the system was included as an additional supply to the Malben-Woolston system.

Projected water demands to the year 2007 indicate that approximately a 20 MGD peak flow will be required in the Malben-Woolston system. Traditional engineering practice is to design for this peak. Since the Missouri River Plant can supply 9 MGD, the additional 11 MGD must come from a groundwater or Tenmile supply. Table 8 outlines options considered most viable and Table 9 shows capital and annual operating costs for each option. Detailed costs are in Appendix 4.

TABLE 8. SUMMARY OF SYSTEM OPERATION OPTIONS

OPTION	EQUIVALENT ANNUAL COST	ADVANTAGE	DISADVANTAGE	CONSTRUCTION REQUIREMENTS
1 MRTP - Prim - 9MGD Grndwtr - Peaking - 11MGD	$1,766,486.00 $1,291,250.00 $3,057,736.00	Secures groundwater for future Some wells may be drilled at a later date	Uncertainty in developing ground water	Well field, 4 1/2 mile pipeline 6 MG reservoir
2 MRTP - Prim - 9MGD Ten Mile - Peaking - 11MGD	$1,766,486.00 $1,610,770.00 $3,377,256.00	Uses or improves existing facilities	Significantly more expensive than other options, foregoes use of groundwater in future	11 MGD treatment plant & booster station, repair Chessman Reservoir
3a Tenmile w/Chessman - 11MGD MRTP - peaking - 9MGD	$1,827,587.00 $1,060,999.00 $2,888,586.00	Uses or improves existing facilities, allows abandonment of existing 24 in line, adds 6 MG storage at little cost	Not as cost effective as Opt.3b foregoes future use of ground water	11 MGD treatment plant & booster station, repair Chessman Reservoir
3b Tenmile w/o Chess. - 10MGD* MRTP - peaking - 9MGD	$1,641,679.00 $1,092,426.00 $2,734,105.00	Abandons Chessman Reservoir	May forego use of groundwater in the future	10 MGD treatment plant & booster station
4 Groundwater - Prim - 11MGD MRTP - Peaking - 9MGD	$1,820,475.00 $1,060,999.00 $2,881,474.00	System matches demand with production	Uncertainty in developing ground water	Well field, 4 1/2 mile pipeline 6 MG reservoir
5a Tenmile - Prim - 11MGD Grndwtr - Peaking - 9MGD	$1,827,587.00 $989,261.00 $2,816,848.00	Provides an alternative to MRTP operation	Uncertainty in developing ground water, debt service on MRTP ($477,066/yr)	10 MGD treatment plant & booster station, wells drilled along influent MRTP pipeline, uses MRTP distribution
5b Tenmile w/o Chess. - 10MGD* Grndwtr - peaking - 9MGD	$1,641,679.00 $1,046,851.00 $2,688,530.00	May be least cost option	Uncertainty in developing ground water, debt service on MRTP ($477,066/yr)	10 MGD treatment plant & booster station, wells drilled along influent MRTP pipeline, uses MRTP distribution

TABLE 9. SUMMARY OF SYSTEM OPERATION OPTION

OPTION	EQUIVALENT ANNUAL COST	CAPITAL COST	EQUIV. ANNUAL OPERATING COST	PRESENT WORTH (1987)
1 MRTP - Prim - 9MGD	$1,766,486.00		$1,135,277.00	
Grndwtr - Peaking - 11MGD	$1,291,250.00	$7,922,315.00	$232,289.00	
	$3,057,736.00	$7,922,315.00	$1,367,566.00	$26,032,230.27
2 MRTP - Prim - 9MGD	$1,766,486.00		$1,135,277.00	
Tenmile - Peaking - 11MGD	$1,610,770.00	$9,575,009.23	$338,228.00	
	$3,377,256.00	$9,575,009.23	$1,473,505.00	$28,752,484.15
3a Tenmile w/Chessman - 11MGD	$1,827,587.00	$9,575,009.23	$555,046.00	
MRTP - peaking - 9MGD	$1,060,999.00		$429,790.00	
	$2,888,586.00	$9,575,009.23	$984,836.00	$24,592,160.97
3b Tenmile w/o Chess. - 10MGD*	$1,641,679.00	$8,243,000.00	$607,000.00	
MRTP - peaking - 9 MGD	$1,092,426.00		$516,000.00	
	$2,734,105.00	$8,243,000.00	$1,123,000.00	$23,276,977.13
4 Grndwtr - Prim - 11MGD	$1,820,475.00	$7,922,315.00	$761,515.00	
MRTP - Peaking - 9MGD	$1,060,999.00		$429,790.00	
	$2,881,474.00	$7,922,315.00	$1,191,305.00	$24,531,612.51
5a Tenmile - Prim - 11MGD	$1,827,587.00	$9,575,002.23	$555,046.00	
Grndwtr - Peaking - 9MGD **	$989,261.00	$1,202,163.00	$198,282.00	
	$2,816,848.00	$10,777,165.23	$753,328.00	$23,981,414.94
5b Tenmile w/o Chess. - 10MGD*	$1,641,679.00	$8,243,000.00	$607,000.00	
Grndwtr - Peaking - 9MGD **	$1,046,851.00	$1,202,163.00	$255,872.00	
	$2,688,530.00	$9,445,163.00	$862,872.00	$22,888,971.47

* Additional 1 MGD supplied from new storage facility at plant

** Includes debt service on Missouri River Treatment Plant ($477,066.00/yr)

The options outlined in Table 8 are a combination of two supply systems one operating as a primary and the others as secondary source. A primary source would operate continuously and supply all water demands up to its capacity. The secondary source would supply the demand in excess of the primary source's capacity only when needed. Typically, the secondary source would operate about four months of the year during the summer.

An important factor that will affect plant operation is reported leakage in the Tenmile 24-inch line which may be as high as 1.5 MGD (pers. comm., Lyle Griffiths, May 1984). If this leakage were eliminated, the estimated peak day demand would fall from 20.1 to 18.6 MGD. However, in the analyses, leakage was not considered. This adds a safety factor making any design conservative.

The equivalent annual costs for the groundwater or Tenmile systems shown below and in Table 9 can be evaluated by comparison with the estimated 1984 City of Helena Water Department budget (including maintenance, repair and capital improvements) of about $2,000,000. Additional capital improvements and operating expenses will add from about $1,600,000 to $1,800,000 to this budget.

Option 1 - Missouri River Plant - Primary
Groundwater System - Peaking

In this option, the Missouri River Plant would operate as the primary plant supplying 1888 MG/year in 1987 and a peak flow of 9 MGD. A

groundwater system would be used to supplement needs of the city in the summer months and would supply 334 MG/year at a peak flow of 11 MGD.

No further construction would be required at the Missouri River Plant. Construction of an extensive East Valley well field, a 24-inch pipeline from the well field to Malben-Woolston reservoirs would be required for groundwater development. Pipeline length is estimated to be 2½ miles from the well field to the distribution system boundary at Custer and Montana Avenues and 2½ additional miles to the Malben-Woolston reservoirs.

Capital Cost $7,922,315 Equivalent Annual Cost $3,057,736

Option 2 - Missouri River Plant would operate as the primary plant supplying 1888 MG/year (1987) with a peak of 9 MGD. Surfce water from Tenmile would supplement the Missouri Plant supplying 334 MG/year and a peak flow of 11 MGD.

Construction of a 11 MGD treatment plant on Ten Mile Creek, repairing of Chessman Reservoir and a booster station at Yaw Yaw would be required. The existing settling and surge pond (6 MG) would be covered and used as a clearwell for finished water. The present 24-inch pipeline from the existing settling pond to Yaw Yaw would be abandoned. No additional construction would be required at the Missouri plant.

Capital Cost $9,575,009 Equivalent Annual Cost $3,377,256

Optional 3a - Tenmile Plant - Primary
Missouri River - Peaking

In this scenario, the Tenmile system would provide 1889 MG/year with a peak of 11 MGD. The Missouri plant would operate only to supply the demand in excess of the Tenmile capacity. The Missouri River plant would provide 333 MG/year and 9 MGD peak.

Construction requirements are the same as Option 2. Operational roles of plants would be reversed.

Capital Cost $9,575,009 Equivalent Annual Cost $2,888,586

Option 3b - Tenmile Plant - Primary
Missouri River - Peaking

This scenario would eliminate Chessman Reservoir from the Tenmile system. The plant would operate at 10 MGD in the summer months using only Scott Reservoir storage. During the remainder of the year it would operate as a run-of-the-stream plant and provide 1889 MG/year. The Missouri River Plant would provide supplementary 333 MG/year and peak flow of 9 MGD.

Since the capacity of the Missouri River Plant is 9 MGD and the Tenmile system is 10 MGD, the combined peak capacity would be 19 MGD. The storage requirement to supply the excess capacity of 1.0 MG is about one million gallons which could easily be supplied by the proposed 6 MG clearwell (see Effects of Increased Storage).

In addition, flows above 19 MGD are projected to occur only about 5 to 10 times between 1997 and 2007. Consequently, a system capacity of 19 MGD would be adequate for all but a very few days in the next two decades.

Construction requirements are the same as 3a except Chessman Reservoir would not be repaired. Plant size would be 10 MGD but the booster station size would be 11 MGD. Additional capacity would allow pumping from the 6 MG storage of the clearwell.

Capital Cost $8,243,000 Equivalent Annual Cost $2,734,105

Option 4 - Groundwater System - Primary
Missouri River Plant - Peaking

This scenario uses a groundwater source in the East Valley as the primary water supply providing 1889 MG/year and a peak flow of 11 MGD. The Missouri River Plant supplements the groundwater supply with 333 MG/year and 9 MGD.

Primary groundwater system construction would be similar to Option 1. No Missouri River Plant construction would be needed.

Capital Cost $7,922,315 Equivalent Annual Cost $2,881,474

Option 5 - Tenmile Plant - Primary
Groundwater System - Peaking

In this option, the Tenmile Plant would supply 1889 MG/year and 11 MGD peak flow. A groundwater system would supplement the Tenmile supply with 333 MG/year and 9 MGD peak flow. Wells would be drilled near the Missouri Plant, the efluent Missouri Plant transmission mains or along the raw water pipeline and would use the existing Missouri Plant distribution system. The Missouri Plant wet well and chlorination facilties would also be used. If sufficient groundwater is not available to meet peak demands, the Missouri River Plant would also be used. Construction of a Tenmile system would be the same as Option 2.

Capital Cost $11,023,662 Equivalent Annual Cost $2,831,311

Option 5b. Tenmile Plant - Primary
Groundwater System - Peaking

This option is the same as 5a except that a 10 MGD Tenmile plant as in Option 3b would be constructed.

Capital Cost $8,243,000 Equivalent Annual Cost $2,688,530

DIRECT FILTRATION

At its April 26, 1984 meeting, the Groundwater Committee directed Hydrometrics to investigate the feasibility of using a direct filtration plant on Tenmile as an alternate to the proposed conventional plant. The advantage of direct filtration is both reduced capital cost required for construction and lower operational costs. Disadvantages are that direct filtration cannot be used for all types

of water and that generally more skilled operation is required to maintain acceptable water quality.

The proposed design of a Tenmile treatment system is a conventional layout with a rapid mix chamber, flocculation/sedimentation basins and dual media filters. Previous work (Morrison-Maierle-Montgomery, 1978) has indicated that conventional treatment may be the most feasible for year-round operation. However, the proposed plant is designed to operate by direct filtration during the fall and winter months and as a conventional plant during the spring and summer when turbidity is reportedly high and taste and odor is a problem.

Review of existing data by Amirtharajah (1984) suggests that the direct filtration process may be feasible for use in place of conventional treatment year round (Appendix 5). Tenmile Creek water appears to be ideally suited for direct filtration except for high algae count. Turbidity does not appear to be a problem.

High turbidities in Tenmile Creek and its tributaries are the result of snowmelt and intense rainfall runoff and can be as high as 300 to 400 NTU (Appendix 6). However, turbidity can be largely controlled by selective use of headgates at the inlets to the Rimini supply pipeline (pers. comm, Lyle Griffiths, May 25, 1984). Turbidity is measured daily at headgates and the influent to the settling pond. In two years of record from May 1982 to the present average turbidities at the settling pond are about 2.7 NTU. The highest turbidity measured was

8.5 NTU on July 14, 1982, which occurred after a severe thunderstorm. This high turbidity lasted about one day. Turbidities less than 5 NTU are normally required for direct filtration operation (Appendix 5). Consequently, if turbidity can be controlled as it has in the past, direct filtration would not be hindered.

Taste and odor are a major problem with Tenmile water and apparently result from the algae growth in Chessman Reservoir. The reservoir is shallow which encourages algae blooms in the summer months. Copper sulfate has been used with good success in the past to hinder algae growth. However, some copper residual has been noted in the water supply. A direct filtration plant would require special design to accommodate the algae problem. Suggested solutions are reservoir management to reduce algae counts or to prevent algae intake to the raw water conduit and addition of a strong oxident such a potassium permanganate in the supply pipeline at Rimini to provide adequate contact time before water reaches the treatment plant. In addition, data indicate that the Tenmile Plant may be operated without Chessman Reservoir. Since Scott is drained every year, it does not presently have an algae buildup.

Morrison-Maierle-Montgomery estimates the cost for a 10 MGD direct filtration plant to be $6,234,000. This estimate is a site-specific design which includes considerable rock excavation.

Other similar treatment plants or designs include recent designs for Bozeman and Missoula. Bozeman recently completed and is operating a 10 MGD plant using surface water from two mountain reservoirs similar to Helena's system. Cost for plant construction was $2.25 million. However, some existing pre-sedimentation basins were used in the new plant design (pers. comm. Neil Mann, July 2, 1984). Some dead bacteriological cysts (giardia) were found in the media filter at plant startup. Consequently, the plant is being operated as if cysts were present. No reported problems have occurred.

The City of Missoula recently considered a 10 MGD diatomaceous earth and a direct filtration plant on Rattlesnake Creek as one of its water supply options. Construction cost of the plant was estimated to be $3.5 million (pers. comm. Jerry Lukasick, July 7, 1984). The direct filtration plant appeared feasible from an operating standpoint but surface water apparently has been abandoned in favor of a groundwater supply system.

In order to evaluate the use of direct infiltration, further investigation would be required. This would include a pilot plant located at the treatment plant site. Cost for this type of study is $50,000 - $75,000. Potential savings range from $1,500,000 to $3,500,000.

INCREASED STORAGE EFFECTS

Finished water or treated water storage can be used to offset the differences between system demands and the capabilities of the source

of supply. Efficient use of storage can reduce the design size of a water supply system and thereby minimize capital requirements.

Analysis of the Helena water production records show an average year-round water requirement exclusive of the Hale/Eureka System of 7.4 MGD ranging from 3.5 MGD average in December to 14.4 MGD in July. The average of the summer months of June, July, and August is 12.9 MGD Figure 12 shows the number of days per year for the year 1987 demand is estimated to be equal to a specified value. Figure 13 is a similar bar chart for the year 2007. Figure 6 depicts the daily fluctuations in demand projected for the design year for the period of May through August.

Figure 14 shows projected water demands in the Upper Malben-Woolston system for the month of July for the design year 2007. The Upper Malben-Woolston system is shown exclusive of the remainder of the system because the capacity of the total of the demands in the Lower Malben-Woolston and Hale/Eureka zones can be satisfied, if need be, by the Missouri River Plant and the Hale/Eureka supplies. The average July 2007 demand in the Upper system is 12.1 MGD (Figure 14); the peak demand is 16.8 MGD.

Analysis indicates that during periods of peak demand, small increases in storage can have an effect on system design size. Table 10 shows the volume of storage required to reduce the peak demands by various amounts from 1 to 4 MGD. This indicates that, theoretically, the

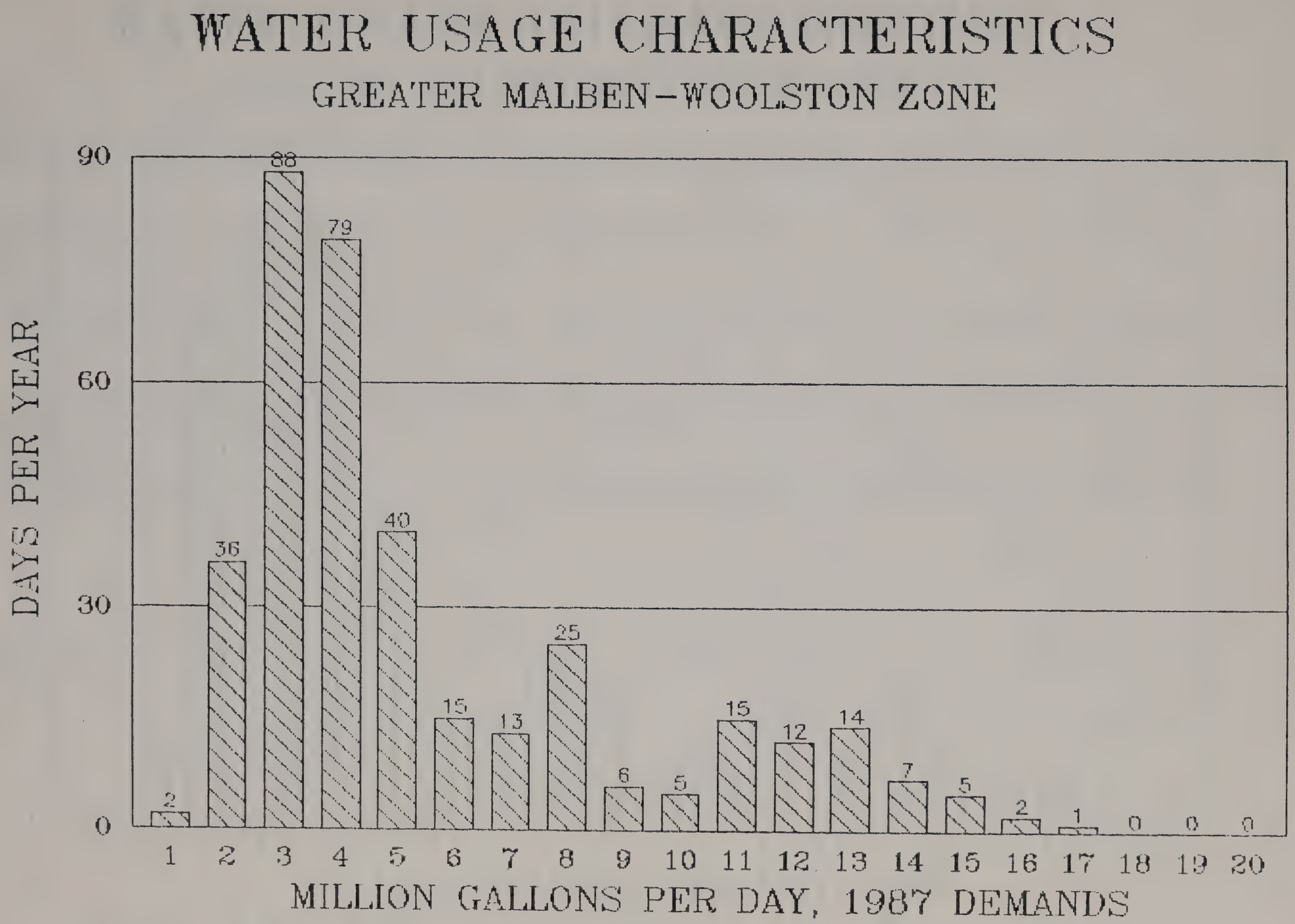


FIGURE 12. YEAR 1987 - PROJECTED WATER DEMANDS IN THE UPPER MALBEN-WOOLSTON ZONE

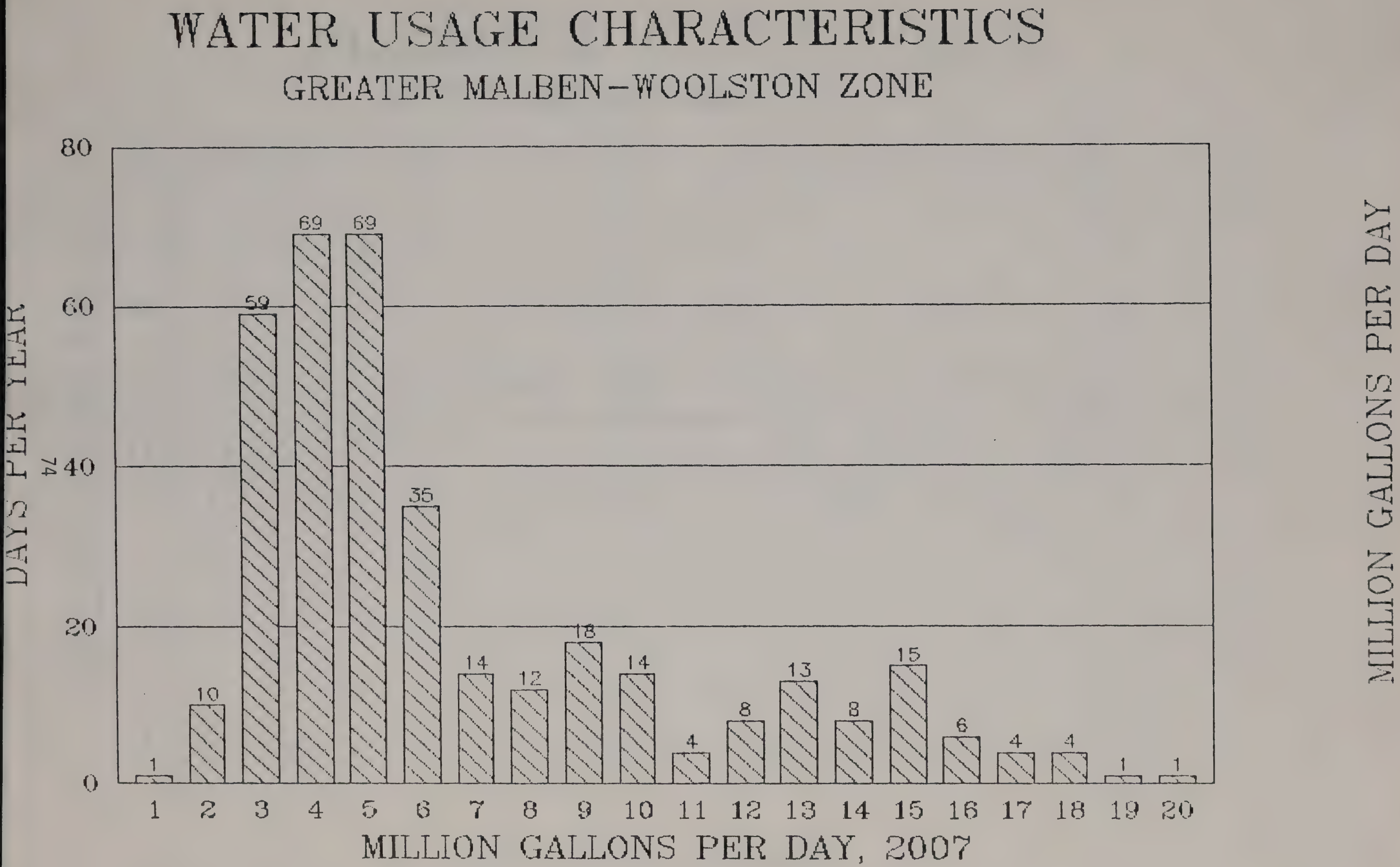


FIGURE 13 - YEAR 2007 - PROJECTED TEN DAY PEAK DEMAND IN THE UPPER MALBEN-WOOLSTON ZONE

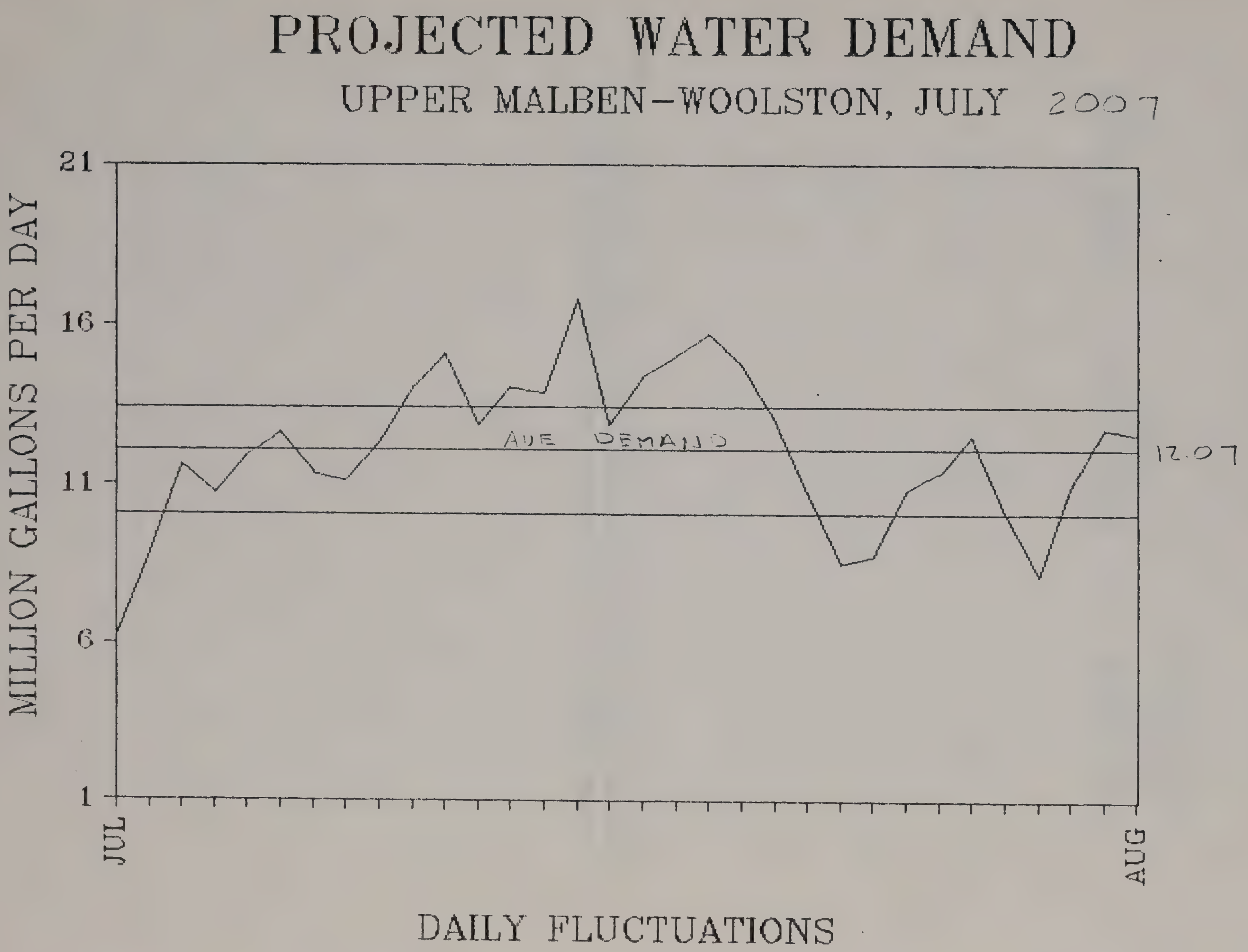


FIGURE 14. PEAK DEMAND 2007

TABLE 10. VOLUME OF STORAGE NEEDED TO REDUCE PEAK DEMANDS IN THE UPPER MALBEN-WOOLSTON ZONE

(Year 2007)

Peak Demand Million Gal/Day	Reduction in Demand Million Gal/Day	Projected Volume of Storage Required Million Gal/Day
16.8	0	0
15.8	1.0	1.0
14.8	2.0	2.0
14.5	2.3	2.5
13.8	3.0	7.8
12.8	4.0	18.7

NOTE: Capacity of existing Missouri River Plant and Hale/Eureka system will meet projected demands in the Lower Malben-Woolston zone and Hale/Eureka zone, respectively, for the 2007 demand.

capacity of the Tenmile or groundwater source could be reduced to 8 MGD if 2.5 million gallons of storage is available. This strategy would provide an effective means of increasing system capabilities in the future. It is not feasible at the present because the Missouri Treatment Plant alone cannot meet average summer demands.

It is important to recognize the limitations of these projections. Specifically, these projections are based upon a limited data base consisting of five years of water production records. Secondly, no attempt has been made to correlate the water use data with temperature and precipitation data and, therefore, it is not certain that a projection given for a specific day will occur. Third, the data did not reflect daily fluctuations in reservoir levels which could tend to accentuate or negate total demands during any given day.

CONSERVATION

In addition to other options, the Groundwater Study Committee requested that effects of various conservation or management programs be investigated. For this study, these options were divided into four areas:

1) Conservation resulting from use of various rate structures including price elasticity;

2) Conservation resulting from use of physical devices in residences;

3) Removal of large users from the system;

4) System management.

PRICE ELASTICITY AND RATE STRUCTURES

Price elasticity in water rates is a measure of the ability of water users to adjust to changes in price. An example of a completely elastic relationship would be when a 30 percent increase in price of water resulted in a 30 percent reduction in water use. Conversely, an inelastic relationship exists if no change in use is noted no matter what the price change is. Observations indicate use by households would be expected to be relatively inelastic at low water usages and somewhat more elastic at high levels of use, other parameters remaining equal. Research supports this observation. Work by Howe and Linaweaver (1967) suggests that winter time use rates by households

change relatively little in response to price changes. Summer use rates, though, are much more responsive to price changes. This supports the thinking that winter time in-house use is for relatively essential purposes: washing, bathing, toilet use and cooking and that summer use is due to increased lawn and yard sprinkling.

Research from 1960 to 1970 indicates that a change from flat rate for water used to metered water usage resulted in a permanent reduction in water use by customers (Hanke, 1970) and (Hanke & Balard, 1971). However, later data on the effects of increased metered rates suggest a strong announcment effect of price changes, causing customer overreaction but that in the long run, customers may gradually adjust to higher prices (Agthe and Billings, 1980). Estimated long-term price elasticity of the Agthe and Billings models varied from -0.27 to -0.49 which means that a 10 percent increase in price would decrease water use by about 2.7 to 4.9 percent.

One researcher noted that although higher prices provide an incentive to be more efficient in summer time use (lawn sprinkling) by using less water per billing period, there is no special incentive to avoid days of extremely high application rates (Howe and Linaweaver, 1967). Typically, high water use in most areas, occurs when customers are free to engage in yard work. Peak use days in Helena are Thursday and Sunday (Charles Dickert, pers. comm., July 16, 1984). Since days of week and hours of the day that users are able to do yard work are

relatively fixed, most pricing methods fail to provide incentive to change this pattern.

The present rate structure used by the City of Helena is the declining block rate. This structure used in many communities in the country is similar to elecric rates used by power companies. The price charged per water unit declines for larger customers. This is normally done because water service to large users of water entails proportionately lower costs of meter reading, billing and collection service than does service to small users (Whipple, 1981). However, many economists point out that this practice does not encourage conservation but rather encourages further use. An increasing block rate in which large users pay more per water unit as volume used increases has been suggested as a better conservation technique (Young, et al, 1983). This follows traditional economic theory that demand will fall as price increases. An increasing rate structure was introduced by Washington Suburban Sanitary Commission in the Maryland portion of Washington, D. C. metropolitan area in 1978. Actual use decreased in 1978 to 1979 and was attributed to the change in rates. Estimated reductions in water use ranged from 1.1 to 8.7 percent (Young, et al, 1983). However, some doubt was raised whether or not the reductions would remain in effect over the long term.

Other recent research indicates that the quantity of water demanded does respond to changes in price. However, the response is relatively inelastic. Inelastic means the percentage decrease in the quantity of

water demanded is less than the percentage increase in price of water. Estimated elasticity is -0.3 which means that a 10 percent increase in price results in a 3 percent reduction in demand (Agthe and Billings, 1980; Hanke, 1970; Hanke and Mehrez, 1979; Young, 1973; and U. S. Army Corps of Engineers, 1979).

Although these studies of price structures vary in detail, the consensus generally is that varying price structures do have an effect on water consumption especially non-esential summertime use. Price increases may reduce Helena's total system demands; however, the reduction in peak demand from varying price structures cannot be accurately determined. Total billed water consumption for the City since the 1982 price increase of 80% would be expected to show a significant reduction. However review of City records shows total consumption appears to have changed only slightly. This is because other factors including weather, increases in population, and removal or large users from the system have a significant effect on water use. Realistically, even if significant price increases reduce average demands up to 20 to 30 percent, additional facilities will still be required to meet peak use.

PHYSICAL DEVICES

The second conservation technique investigated is the use of devices installed in residences to reduce flow without inconveniencing the homeowner. Three devices considered most effective are:

1) Toilet dams,
2) Water saving shower heads,
3) Water saving faucets.

A study of the cost-effectiveness of these devices using Helena as an example was done by Cartwright (1983). The results of the study indicate that a total savings of 12 percent of base flow or about 575,000 GPD of water treated could be saved. However, little additional reduction in peak demand can be made with these types of conservation devices.

The study estimated that the three water saving devices could be installed by a contractor or city personnel for about $500,000. It was assumed that about 85 percent of the homes in Helena could be fitted with the devices if no charges were made to the homeowner and an informational program was initiated to inform homeowners the devices were to save money for them. A similar pilot program was conducted in Hamilton Township, New Jersey, in which an 88 percent acceptance was reported.

If an acceptance level of 85 percent was achieved, savings would be about $130/year in operation and maintenance costs for a groundwater supply system and $90.00/year for a Tenmile system. This is not a very attractive return on a $500,000 investment. In addition, a peak reduction of one-half million gallons per day probably would not reduce

the design size unless it was done in conjunction with other conservation measures.

REMOVE LARGE USERS FROM SYSTEM

Although not strictly a conservation measure, removal of large users from the system would in effect increase the capacity of the system to serve the users remaining on the system. The seven largest users on the Helena system that potentially could develop their own water supply system are:

1) St. Peters Hospital
2) Fort Harrison VA Center
3) Capitol Complex
4) Carroll College
5) Highway Department Complex
6) Highway Department Watering
7) City Parks

Total average monthly summertime usage by these users is about 0.44 MGD. All of the users except the Capitol complex and the City of Helena have either drilled wells in the past and have not found sufficient water or have drilled wells and are presently supplementing their irrigation needs with groundwater. The largest non-city user is the V.A. Hospital. Until recently, it used city water entirely. However, two wells producing approximately 250 gpm each have been drilled and developed. The wells are expected to replace city water for irrigation uses in fall 1984 (pers. comm. Robert Dunn, June 21, 1984).

The largest city use of water is for lawns and parks. It would not be economical or even possible to drill a well at each park site solely to provide irrigation water. Similarly, it is questionable whether groundwater of sufficient quantity or quality is available for the capitol area.

Given the constraints mentioned above, the most water that could be saved would allowing or requiring those large users that partialy use groundwater to rely on groundwater as their primary source. Total average savings is estimated to be about 0.20 MGD. Since the total peak average demand is 20.1 the amount saved by removing large users would not significantly reduce the flow required by the system. Thus, removing large users from the system does not appear to be a particularly effective means of reducing water demands.

EFFECTIVE MANAGEMENT

While rate structures, physical devices and removal of large users will have a conserving effect on the total water consumption in the Helena service area, none of the options will significantly affect the most critical part of the demand curve, the peak use on a hot summer day. Figure 12 and 13 show the estimated number of days in 1987 and 2007 in which peak demands occur. As can be seen, a 20 MGD peak in the Upper Malben-Woolston zone will occur only once in the year 2007. Thus, it is estimated that peak flows above 19 MGD occur only 5 to 10 times between 1997 and 2007. Rate structures and metering devices which encourage off peak use for summer irrigation are conceivable. However,

at this time, water meters which record use on a daily time basis are not readily available. Until a device of this sort is available, the most effective measures in reducing peak demands are management related, especially watering restrictions. Management and enforcement of a watering restriction program is the most effective albeit unpopular method of reducing peak use. Since peak use is the traditional accepted manner in sizing water systems, a close look at a water management program could reduce the size and capital cost required for meeting Helena's future water needs.

Current measures being implemented by the City include replacement of flat rates with meters, leak detection and small main replacement, and old meter replacement. Currently the City replaces about 800 meters annually and has an active program of replacing 4 inch with 12 inch mains to reduce leaks and improve fire flow capabilities.

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APPENDIX 1

TEST HOLE LOGS FOR TENMILE CREEK
AND WEST HELENA VALLEY
GROUNDWATER INVESTIGATION

HYDROMETRICS

TEST HOLE LOG

Helena, Mt.

State: Montana County: Lewis & Clark Project: City of Helena Hole Name or Number: GM-1

Legal Location: T 10N R 4W Sec 14 Tract AD Descriptive Location: North end of golf course; 100 feet east of Ten Mile Creek

Recorded by: DR/DCP Date Hole Started: 2-17-84 Date Hole Completed: 2-20-84 Driller: Terry Drilling Company: Lindsay

Drill Method: Rotary Drilling Fluids Used: Water/Foam Pilot Hole Diameter: 6 inch Reamed Hole Diameter:

Total Depth Drilled: 180 ft Total Depth Reamed: Total Depth Cased Below G.S.: 120 ft Diameter and Type of Casing: 6 in. steel

Weight or Gage of Casing: 25 wall Interval Perforated or Screened Below G.S.: None Target Aquifer: Alluvium Packer Type and Depth Below G.S.: None

	YES	NO
Well Developed?		X
Well Test Pumped?		X
Water Samples Taken?		X
Material Samples Taken?	X	
E - Logs?		X

Method Perforated or Screened:

- ___ No casing in hole.
- X Open bottom only.
- ___ Slotted with Mill's Knife.
- ___ Slotted with a torch.
- ___ Screened by pulling casing.
- ___ Saw cut
- ___ Other (specify)

Static Water Level: 7.29 Date: 2/21/84

Measuring Point Description/Elevation: Top of steel casing. MP Height Above (±) or Below G.S.: 2.0

Well Annulus Completion Description: Driven steel casing to 120 feet.

Remarks:

From	To	DRILLING LOG Geological, Drilling, and Water Conditions and Sampling
0	3	Topsoil
3	62	Sand & gravel; mostly sand; coarse grained; little clay; moist; lithology primarily dark argillite (?); also igneous lithologies; coarser gravels at 25 feet; making little water; more fines and clay from 30 - 40 feet, making 5 - 10 gpm at 60 - 62 feet. Silt, sand and clay with gravel stringers 40 - 62.
62	120	Casing hammer quit working at 62 feet. Drilled open hole with foam from 62 - 85 feet, then drove casing with rock hammer bit. Drilled open hole again from 82 - 120 feet. Silt and clay; scattered gravels; some sand; making little water; gravels vary from sub-rounded to angular.
120	156	Clayey gravel; mostly granitic; tan to yellow brown tight. Cased to 120 feet; 2-17-84.
156	180	Bedrock, tan to buff quartzite, yellow brown soft zones; makes approximately 10 gpm in bedrock; hole caved a little.

HYDROMETRICS

TEST HOLE LOG

Helena, Mt.

State: Montanta County: Lewis & Clark Project: City of Helena Hole Name or Number: GM-2

Legal Location: T 10N R 4W Sec. 14 Tract. DB Descriptive Location: 50 feet west of Ten Mile Creek, 300' from RR tracks

Recorded by: DCP/DR Date Hole Started: 2/20/84 Date Hole Completed: 2/21/84 Driller: Terry Drilling Company: Lindsay

Drill Method: Rotary Drilling Fluids Used: Foam Pilot Hole Diameter: 6 inch Reamed Hole Diameter:

Total Depth Drilled: 245 ft Total Depth Reamed: Total Depth Cased Below G.S.: 102 ft Diameter and Type of Casing: 6" steel

Weight or Gage of Casing: .25 wall Interval Perforated or Screened Below G.S.: None Target Aquifer: Alluvium Packer Type and Depth Below G.S.: 6" steel

	YES	NO
Well Developed?		X
Well Test Pumped?		X
Water Samples Taken?		X
Material Samples Taken?	X	
E - Logs?		X

Method Perforated or Screened:

☐ No casing in hole.
☒ Open bottom only.
☐ Slotted with Mill's Knife.
☐ Slotted with a torch.
☐ Screened by pulling casing.
☐ Saw cut
☐ Other (specify)

Static Water Level: 12.37 Date: 3/14/84

Measuring Point Description/Elevation: Top of steel casing. MP Height Above (±) or Below G.S.: 2.1

Well Annulus Completion Description: Driven steel casing to 102 feet.

Remarks:

From	To	DRILLING LOG Geological, Drilling, and Water Conditions and Sampling
0	35	Gravel; sandy, gray, making little water; argillites, quartzites, and volcanics; some clay
35	40	Quartzitic volcanic boulder; dark green-black, hard to drill
40	45	Gravel; sand; brown, clayey and silty
45	55	Gravel and sand; moderately clean - not much water
55	85	Clay; tan; some sand & gravel
85	95	Abundant gypsum (?) fragments in clay matrix; occasional gravels
95	100	Clayey gravels; darker colored, weathered gravels
100	115	Gravels; coarser and cleaner, light and dark colored quartz, feldspars; green colored hard fragments, rose colored clay, start open hole at 102 feet; very little clay matrix
115	135	Gravels; fragments of both weathered igneous and sedimentary lithology. Variable colors. Rose colored clay.
135	245	Granitic bedrock, weathered, redish tan clay zones. Primarily feldspar, quartz, chlorite and amphibole. Making approximately 30 gpm at 135 feet. Colors variable - light greens, rose, browns (weathered), hard and soft zones intermixed; making about 40 gpm at 245 feet. A few diorite (?) chips.

HYDROMETRICS

TEST HOLE LOG

Helena, Mt.

State: Montana
County: Lewis & Clark
Project: Helena GW
Hole Name or Number: TW-1

Legal Location: T 10N R 5W Sec. 34 Tract DD
Descriptive Location: About 500 ft. south of holding reservoir

Recorded by: DR
Date Hole Started: 12/5/83
Date Hole Completed: 12/9/83
Driller: Terry
Drilling Company: Lindsay

Drill Method: Rotary
Drilling Fluids Used: Water
Pilot Hole Diameter: 6 in.
Reamed Hole Diameter: 8-5/8 in.

Total Depth Drilled: 62 ft.
Total Depth Reamed: 20 ft.
Total Depth Cased Below G.S.: 47 ft.
Diameter and Type of Casing: 6-in. steel

Weight or Gage of Casing: 0.250
Interval Perforated or Screened Below G.S.: None
Target Aquifer: Alluvium
Packer Type and Depth Below G.S.: None

	YES	NO
Well Developed?		X
Well Test Pumped?		X
Water Samples Taken?		X
Material Samples Taken?	X	
E - Logs?		X

Method Perforated or Screened:
___ No casing in hole.
X Open bottom only.
___ Slotted with Mill's Knife.
___ Slotted with a torch.
___ Screened by pulling casing.
___ Saw cut
___ Other (specify)

Static Water Level: 32.75 Date: 1-20-84

Measuring Point Description/Elevation: Casing top
MP Height Above (±) or Below G.S.: 2.45 feet

Well Annulus Completion Description:

Remarks: Total depth measured with probe on 1-20-84 = 61 feet.

From	To	DRILLING LOG Geological, Drilling, and Water Conditions and Sampling
0	20	Sand; silty, gravelly; mixed lithology; boulders to 2 ft. diameter. Stopped drilling on Dec. 6 due to rig breakdown; resumed drilling Dec. 9.
20	47	Sand in poorly sorted silts & gravels; mostly coarse to very coarse; mixed lithology; dry; brown-black-gray; boulders to 5 ft. diameter; rock hammer needed for large boulder; ruined new tri-cone bit; changed to rotary tri-cone button bit. Making less than 1 gpm.
47	62	Bedrock; quartz diorite; gray-green; clean cuttings; no weathering; mostly quartz and mica biotite; could not drive casing into bedrock; blew hole for 5 minutes and making less than 1 gpm.
		T.D. = 62 ft. Alluvium = 0-47 ft. Bedrock = 47-62 ft.

HYDROMETRICS

TEST HOLE LOG

Helena, Mt.

State: Montana County: Lewis & Clark Project: Helena GW Hole Name or Number: TW-2

Legal Location: T. 9N R. 5W Sec. 2 Tract. BB Descriptive Location: About 1500 ft. south from holding reservoir

Recorded by: DR Date Hole Started: 12-9-83 Date Hole Completed: 12-9-83 Driller: Terry Drilling Company: Lindsay

Drill Method: Rotary Drilling Fluids Used: Water Pilot Hole Diameter: 6 in. Reamed Hole Diameter: 8-5/8 in.

Total Depth Drilled: 89 ft. Total Depth Reamed: 20 ft. Total Depth Cased Below G.S.: 54 ft. Diameter and Type of Casing: 6-in. steel

Weight or Gage of Casing: 0.250 Interval Perforated or Screened Below G.S.: None Target Aquifer: Alluvium Packer Type and Depth Below G.S.: None

	YES	NO
Well Developed?		X
Well Test Pumped?		X
Water Samples Taken?		X
Material Samples Taken?	X	
E - Logs?		X

Method Perforated or Screened:

- ___ No casing in hole.
- X Open bottom only.
- ___ Slotted with Mill's Knife.
- ___ Slotted with a torch.
- ___ Screened by pulling casing.
- ___ Saw cut
- ___ Other (specify)

Static Water Level: 40.18 Date: 1-20-84

Measuring Point Description/Elevation: Casing top MP Height Above (±) or Below G.S.: 2.40 feet

Well Annulus Completion Description:

Remarks: Total depth measured with probe on 1-20-84 = 50 feet.

From	To	DRILLING LOG Geological, Drilling, and Water Conditions and Sampling
0	50	Sand; silty, gravelly; igneous lithology; mostly dark; boulders up to 3 foot diameter; black-brown color; dirty, dry; moist at 40 ft. making 1 to 3 gpm 45-50 ft.; mostly coarse to very coarse.
50	89	Bedrock; quartz diorite; decomposed, weathered. Soft; reddish-orange-brown staining; drills fairly easy first 20 feet. Drilling becomes harder at about 70 feet with less red color. Open hole from 54 to 88 feet making less than 3 gpm. Could not drive casing into bedrock.
		T.D. = 89 ft.
		Alluvium = 0-50 ft.
		Bedrock = 50-89 ft.

HYDROMETRICS

TEST HOLE LOG

Helena, Mt.

State: Montana
County: Lewis & Clark
Project: Helena GW
Hole Name or Number: TW-3

Legal Location: T 9N R 5W Sec. 2 Tract BC
Descriptive Location: Along fence/raceway south end of upper cross-section

Recorded by: DR
Date Hole Started: 12/12/83
Date Hole Completed: 12/12/83
Driller: Terry
Drilling Company: Lindsay

Drill Method: Rotary
Drilling Fluids Used: Water
Pilot Hole Diameter: 6 in.
Reamed Hole Diameter: 8-6/8 in.

Total Depth Drilled: 89 ft.
Total Depth Reamed: 20 ft.
Total Depth Cased Below G.S.: 61 ft.
Diameter and Type of Casing: 6 in. steel

Weight or Gage of Casing: 0.250 in
Interval Perforated or Screened Below G.S.: None
Target Aquifer: Alluvium
Packer Type and Depth Below G.S.: None

	YES	NO
Well Developed?		X
Well Test Pumped?		X
Water Samples Taken?		X
Material Samples Taken?	X	
E - Logs?		X

Method Perforated or Screened:

- No casing in hole.
- X Open bottom only.
- Slotted with Mill's Knife.
- Slotted with a torch.
- Screened by pulling casing.
- Saw cut
- Other (specify)

Static Water Level: 48.14 Date: 1-20-83

Measuring Point Description/Elevation: Casing top
MP Height Above (±) or Below G.S.: 1.8 ft.

Well Annulus Completion Description:

Remarks: Open hole 61-89, hole blows 1 gpm. Total depth measured with probe on 1-20-84 = 68 feet

From	To	DRILLING LOG Geological, Drilling, and Water Conditions and Sampling
0	57	Sand and gravel; silty; coarse to very coarse; mostly igneous rocks-granite & quartzite; brown-black; scattered small boulders; 3 ft. diameter boulder at 37 ft.
57	89	Bedrock; quartz diorite; yellow-brown, drills easily, weathered, cuttings fine to medium sand granite, yellow-brown to gray-brown, gets grayer with depth, hard.
		T.D. = 89 ft. Alluvium = 0-57 ft. Bedrock = 57-89 ft.

APPENDIX 2

PROJECTED WATER SERVICE POPULATION FOR THE CITY OF HELENA

WATER REQUIREMENTS

INTRODUCTION

Through the years, there have been numerous attempts to qualify and quantify what is expected to occur in Helena and the areas surrounding Helena in the coming years. There have been economic plans, comprehensive plans, housing plans, wastewater facility plans, water plans and transportation studies in which the common denominator is what the service area and population will be. From a purely mathematical standpoint, given peoples' preferences for various types of housing, it is a simple matter to project the population any given property will support. However, it is the responsibility of planners and politicians to define what properties will be considered for inclusion in a particular plan and to define what types of development will be permitted on those properties. The consequences of these decisions by planners, and more particularly politicians, can be, and often are, dramatic. The objective of the following discussion is to correlate and put into perspective the Water System Improvement and Master Plan for the City of Helena (April 1978) with the Helena Comprehensive Plan (1981) and the Lewis and Clark County Comprehensive Plan (1983) and arrive at a reasonable estimate of service area and service population for the Helena water system. It is strongly recommended this report be appended to all three of the above referenced plans so a false impression of the situation not appear in the future.

Service Area and Population:

Table XI reproduced below from the Helena Comprehensive Plan (City Plan) shows the projected populations for Lewis and Clark County, the City, and Helena and the Surrounding Area.

TABLE XI - COMPREHENSIVE PLAN PROJECTIONS

	1980	1990	2000
County	43,050	49,500	57,000
City	23,938	26,550	28,759
Helena & Surrounding Area	30,500	34,450	38,500
Surrounding Area	6,550	7,900	9,700

Table XI shows the Helena water system serving a population of 38,500 in the year 2000. This figure, 38,500, was the basis for testimony by Mr. Richard Nisbet, Director of Public Works for the City of Helena, before the Montana Public Service Commission in 1982(1) whereby the City of Helena amended its water tariff filing to show a maximum daily system demand of 28 milion gallons per day (mgd). This maximum daily demand represents a significant departure from the Water System Improvement Program and Master Plan for the City of Helena.

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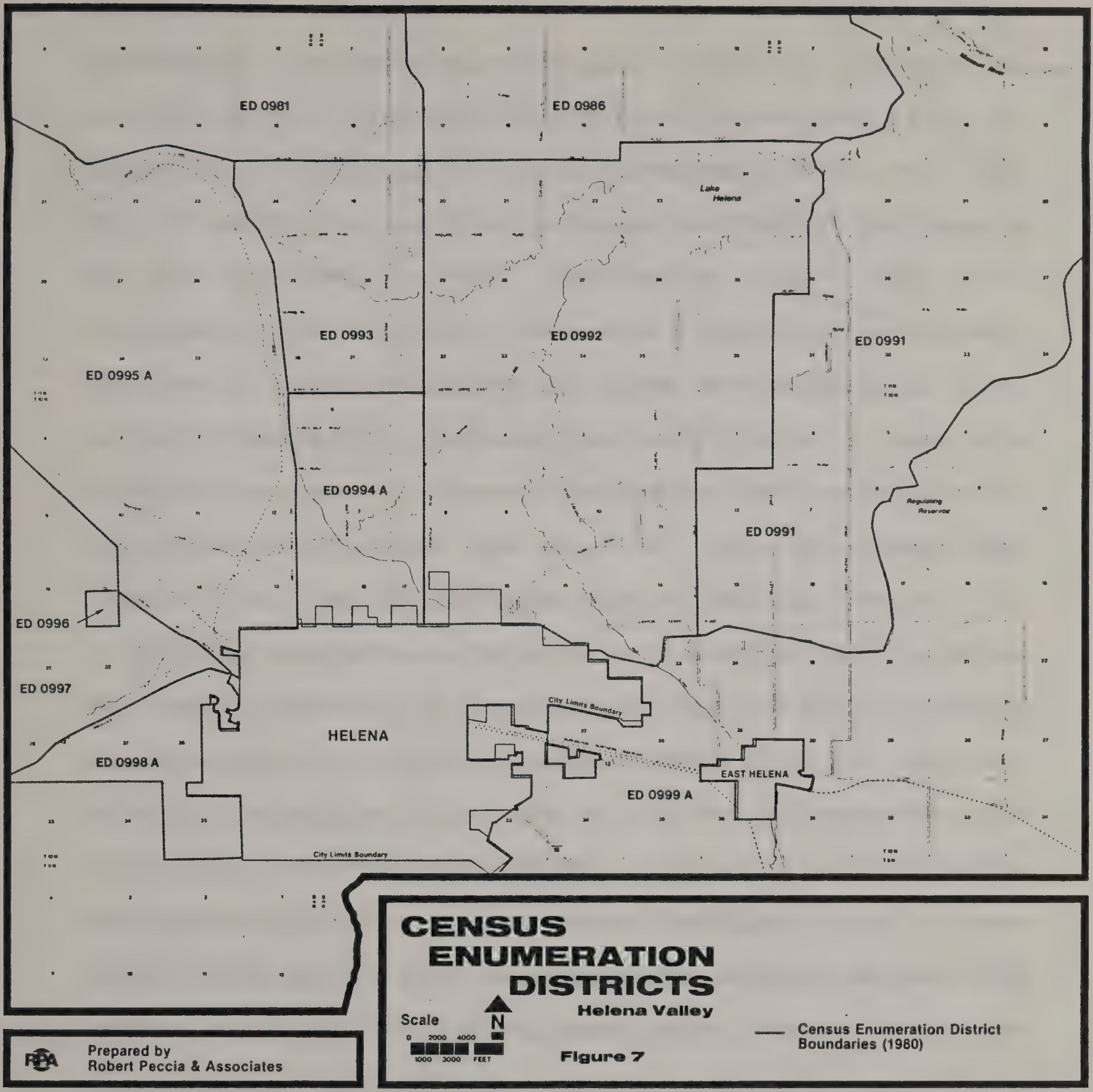
(1) Department of Public Service Regulation before the Public Service Commission docket No. 82.1.3 Order No 4927, page 11.

At the time the Water Master Plan was prepared, the Helena Area, except possibly the City of Helena, was experiencing a period of unprecidented development. Concerns were raised during the Water Master Planning effort about the potential impacts of this develepent on the groundwater quality in the Helena Valley and the likelihood that City water and sewer services would have to be extended to this area during the planning period. Therefore, the Helena City Commission working with the Areawide Planning Organization and their consultants made the decision to focus the Water Master Plan on an expanded planning area. This expanded planning area encompassed a geographical area substantially beyond the City limits. However, it was, and probably still is, a reasonable estimate of the area that eventually will require centralized service whether it be from the City of Helena or some other utility.

The population of the Helena Valley, according to the 1980 census figures reported in the Lewis and Clark County Comprehensive Plan (Table 2, page 21) was 13,287. The Helena Valley is defined in the County Plan as encompassing Enumeration Districts 981, 986 and 991 through 999A. These districts extend as far north to the Missouri River, east to Canyon Ferry, South to Jefferson County, and west to Birdseye and the Blue Cloud Ranch. Table 2 and Figure 7 of the County Plan are reproduced here by permission for reference.

Referring to Table XI of the City Plan, the population of the area surrounding Helena was 6,550 in 1980 and is projected to be 9,700 in



CENSUS ENUMERATION DISTRICTS

Helena Valley

Figure 7

Census Enumeration District Boundaries (1980)

Prepared by Robert Peccia & Associates

the year 2000. To correlate the City Plan with the County Plan, surrounding is assumed to mean contiguous to the City. Applying this rationale to the figures contained in Table 2 of the County Plan, and subtracting the populations attributed to Enumeration Districts 981, 986, 991 and 993, the population in Enumeration Districts contiguous to the City was 9,829 in 1980. Enumeration District 992, while contiguous to the City, does not have any substantial development contiguous to the City except for the limited development at the intersection of Canyon Ferry Road with York road. Similarly, there is no significant development in Enumeration District 999A contiguous to the City limits at the present time except for limited development along Highway 12 east near the Burlington Northern Railroad overpass. Subtracting the populations attributed to Enumeration Districts 992 and 999A leaves a population in the surrounding area of 5,639, a reasonable approximation of the 6,550 reported in Table XI of the City Plan. Table XI also projects a population of 9,700 for the surrounding area with a City population of 28,759 for a total Helena and surrounding population of 38,500 in the year 2000. The 38,500 figure, as previously noted, was the basis for reducing the projected maximum daily requirements of the City of Helena water system. However, for reasons discussed below, the 38,500 figure may also overstate the population to be served by the Helena system in the year 2000.

Refering to Figure 7 of the County Plan, the City made a decision not to pursue service to Enumeration Districts (ED) 994A and 992 to the

immediate north and central of the Helena City limits in 1982. This is evidenced by:

1) The decision to design a 20-inch diameter transmission main from the Missouri River Treatment Plant to the City via a 24-inch diameter main;

2) The decision not to construct an influent pump station to the Missouri River Treatment Plant that would have permited the plant to produce 12 million gallons per day, and

3) The decision to design the clearwell on the basis of the chlorine contact time afforded by the time the water was in transient in the pipe line. (Affects only ED 992. The City sought and received a variance from the Montana Department of Health and Environmental Science to allow computation of the chlorine contact time based upon the detention time in the clearwell and the transmission main flowing at 12 million gallons per day. This variance does not permit any service lines or distribution system lines off the transmission main between the Missouri River Treatment Plant and Washington Street).

The decision not to serve these districts was predicated on several considerations:

1) There had been no request for service in these areas and no requests for annexation.

2) Statutory limits precluded the City from annexing these areas without being petitioned. (These districts are inclusive to existing rural fire districts.)

3) There were probably less costly alternatives to supplying water to this area (scattered high capacity wells).

4) The rate payers, the City Commissioners; the Public Service Commission; and the Montana consumer council could not justify the large capital outlay and resulting high service charges necessary to provide service without a guarantee these areas would be served in soon and thereby contribute to the payback of the facilities.

This is not to say these areas could not be served in the future, they could be, subject to the conditions they bear the cost of installing additional equipment at the Missouri River treatment plant:

1) An influent pump station;

2) Additional high service pumps;

3) Clearwell expansion to provide the necessary chlorine contact time (Affects only ED 992).

4) A parallel transmission main to the present 20-inch diameter transmission main.

The probability of a significant block of people desiring service and willing to accept these conditions is believed to be remote. Therefore, the population projections of ED's 994A and 982 should not be included in the year 2000 estimate. Likewise, ED 995A should not be included in the population projects because the majority of ED 995a contiguous to the City limits on the northeast is located in the flood plain of Ten Mile Creek and/or is subject to high groundwater. Lewis and Clark County has established building restrictions for this area. The restrictions, if development is permitted at all, will require centralized sewer system. The cost to provide both centralized water and sewer to this area is not believed to be an economical alternative to developing other sites around Helena. Green Meadow Country Club also occupies a substantial portion of this district contiguous to the City which is not expected to be subdivided for living.

Enumeration Districts 996, 0997 and 998A for the most part receive service now. City records obtained from Richard Nisbet, Director of Public Works for the City of Helena, show 421 water accounts in these areas. Current City policy is not to provide service unless the party requesting service agrees to annexation. This and the the steep terrain existing over much of the area that could be developed contiguous to the city limits future impact of these districts on the Helena Water System.

TABLE 2. LEWIS AND CLARK COUNTY COMPREHENSIVE PLAN 1983
1980 HELENA VALLEY POPULATION+
BY CENSUS ENUMERATION DISTRICTS

District	Population	Household	Average Household Size
ED 0981	750*	294	3.5
ED 0986	240*	97	3.3
ED 0991	796	248	3.2
ED 0992	1,513	487	3.1
ED 0993	1,672	528	3.2
ED 0994A	3,024	1,013	3.0
ED 0995A	1,674	607	2.7
ED 0996	77	25	3.1
ED 0997	214**	75	2.8
ED 0998A	650**	228	2.8
ED 0999A	2,677	915	2.9
Totals	13,278	4,517	2.9

Comparative Average Household Sizes

Lewis and Clark County	2.6
City of Helena	2.4
City of East Helena	2.6

Marked figures represent percentage of Enumeration District total that is within the Helena Valley:

* 75%
** 50%

+ Excluding cities of Helena and East Helena

Source: 1980 Census, Research and Information Systems division, former Montana Department of Community Affairs (now Department of Commerce), Areawide Planning Organization.

Based upon these observations, the only area that could materially affect Helena's water supply system is Enumeration District 999A. The development potential in ED 999A adjacent to the City, based upon present land use characteristics is 2,144 capita (i.e. Bull Run, PUD No. 2, etc. - see Table 6.1 of the Water Master Plan). The present service population for the Helena Water System through the year 2000 are summarized below.

PRESENT AND PROJECTED WATER SERVICE POPULATIONS

Enumeration District	Helena Valley 1980 District Population	City of Helena Surrounding Area Population	1980 Service Population	2000 Service Population
981	750	0	0	0
986	240	0	0	0
991	796	0	0	0
992*	1,513	(1)	0	0
993	1,672	0	0	0
994A*	3,024	3,024	0	?
995A*	1,674	1,674	0	?
996	77	77	77	77+?
997	214	214	214	214+?
998A*	650	650	650	650+?
999A*	2,677	(1)	0	?
Total	13,287	6,550	941	941+?
City(City Plan)	23,938	23,938	23,938	28,759
Total	37,225	30,500	24,879	29,700+? (Max, 38,500)

*Districts Surrounding Helena

(1) Estimated from the City Plan. 992 and 999A, together, equal population of 911.

Table VII of the City Plan, a portion of which is reproduced here shows the census population of the City of Helena from 1920 through 1980. However, the city limits of the City of Helena in 1920 was different from what it was in 1930, 1940, etc., and 1980 will probably be different than 1990, 2000, 2010. Therefore, there is strong reason to believe the 2,144 projected residents surrounding the City of Helena on the southeast are included in the 4,821 projected growth for the City of Helena. This suggests that the projections for the City of Helena in 2000 include the present surrounding area and that this area has been counted twice. Therefore, since ED 999A is the only district in which substantial growth is projected, the estimated service population of Helena is the same as projections for Helena within the city limits.

On the basis of the projected growth rate of 20 percent for the City of Helena from 1980 to 2000 (Table VII, City Plan), and upon the assumption the City Commission will continue to enforce its policy of requiring annexation as a condition to receiving service. The year 2000 service population is 28,759. Adding the 941 persons residing outside the city limits who presently receive service, the total is 29,700. Service populations using a 20-year life of plant constructed in 1987 are estimated as follows:

TABLE VII HELENA COMPREHENSIVE PLAN, 1981
HELENA AND LEWIS AND CLARK COUNTY CENSUS POPULATION

City	1920	1930	1940	1950	1960	1970	1980
Helena	12,037	11,803	15,956	17,581	20,227	22,730	23,938

PROJECTED SERVICE POPULATION - HELENA WATER SYSTEM

Year	Population	Year of Plant Life
1980	24,900	-----
1987	26,500	0
1992	27,664	5
1997	28,900	10
2000	29,700	13
2002	30,200	15
2007	31,600	20

City building permit records show an average of 100 living units per year over the last four years being constructed in Helena. Based upon the occupancy rate of 2.4 persons per household rate reported in the 1980 Census, the service populations appear reasonable.

Service Population Distribution:

The distribution of the service population throughout the service area is important to the evaluation of water supply alternatives; i.e., capacity and location of treatment plants, wells and reservoirs.

There are three major and two minor service areas to the Helena water system. The major areas, corresponding to the systems that feed them, are the Malben-Woolston, the Hale and the Winne. The minor systems are the Upper Hale and the Upper West Side. Service areas and reservoir systems may be used interchangeably. The distinguishing features of the reservoir system service areas, are the elevations at which the

reservoirs are located and the pressures sustained in the system they feed. Figure 6-1 of the Water Master Plan shows the respective service areas also referred to as zones. For a more detailed discussion of the service areas refer to the Water Master Plan, Chapter 6.

The Hale System including Upper Hale is self-sufficient. Its supply, Orofino Gulch and Eureka Well are capable of meeting both present and future maximum demands without need for importing water. In fact, Eureka well has occasional excess capacity during off peak times that can be and is used to supply water to the Malben-Woolston System. The Malben-Woolston System, itself, is divided into two distinctive pressure zones by pressure regulating valves on all mains crossing the Burlington Northern Railroad tracks. These two ones are known as the Upper and Lower Malben-Woolston Systems, respectively. The Winne System and Upper West Side System are both pumped supplies that derive their water from the Upper Malben-Woolston system. Therefore, in essence, there are three principal service areas - Hale, Upper Malben-Woolston and Lower Malben-Woolston.

The 1980 Census block data for the City of Helena obtained from the Montana Department of Commerce showed the population of Helena residents north of the Burlington Northern Railroad corresponding to area census area 9901 to be 3661. The population served by the Hale System, corresponding to block group 6 of census area 9903 and block group 6 of census area 9904 less blocks 601, 603, 615, 616, 617 and 628

to be 2572. This leaves 18,667 people residing in the Upper Malben-Woolston, Winne, and Upper West Side areas.

APPENDIX 3

CITY OF HELENA WATER SUPPLY COMPLIANCE SCHEDULE

Attachment "C"

SAFE DRINKING WATER ACT
APPLICATION FOR EXEMPTION
CITY OF HELENA, MONTANA

15. Expansion of system capacity during exemption period.

The capacity of Helena's Missouri River Treatment Plant will be increased by May 1984 so it can provide approximately 9.75 million gallons per day. (See Attachment "E")

23. Explanation of any other compelling factors preventing compliance.

The City of Helena has experienced water rate increases in the following years: 1958, 1977, 1978 and 1979; along with the proposed rate increase of 1982. The proposed 1982 rate increase will increase charges from 80 to 150 percent to the users. This increase, combined with the other two recent increases, amounts to four increases in six years. These recent increases are a compelling deterrent to another rate increase in order to construct a treatment plant adequate to meet the MCL standard.

During the months of November through May, it will be necessary to maintain a flow of one million gallons per day through the settling pond, regardless of the turbidity, in order to preclude freezing of the settling pond and the transmission mains. At all times, a minimum flow will have to be maintained, regardless of the turbidity, in order to provide sufficient volumes of water for the downstream users that cannot be served by Missouri River water.

24. Describe your plan for providing safe drinking water in case of an excessive rise in contaminant level for which the exemption is requested.

A. WATER SYSTEM OPERATION - PHASE I (1982 - Jan 1, 1984)

1. The Ten Mile System will be shut down if it exceeds the predetermined turbidity units (10NTU) and the City will operate the Missouri River Treatment Plant at a minimum flow of 1.8 million gallons per day for an average of six days per week, except during shutdown for construction or necessary maintenance.

2. A minimum total chlorine residual of .3 mg/l will be maintained throughout the distribution system. The City will do monitoring of chlorine residuals throughout the system, and submit the results of the monitoring to assure the maintenance of the minimum residual. The monitoring will be done on Monday and Thursday of each week at the following locations: 2501 Belt View, Forrest Estates Pump Station, Husky Truck Stop, Wastewater Treatment Plant, Cooney Convalescent Home, and Fort Harrison. The results of the monitoring will be submitted to the Water Quality Bureau on the following Wednesday.

3. An in-line turbidimeter and manual valves will be placed in operation on the Ten Mile System. Purpose of the valves will be to shut down the system when the water reaches a turbidity of 10 NTU.

B. WATER SYSTEM OPERATION - Phase II (Jan 1, 1984 - June 1, 1984)

1. The Department of Health and Environmental Sciences will grant a 5.0 NTU waiver to the City of Helena's Ten Mile System under the provisions of ARM 16.20.205.

2. The operation of the manual valves will be changed so that the Ten Mile System will be shut down at a turbidity of 5.0 NTU. The City will operate the Missouri River Plant at a minimum flow of 1.8 MGD for an average of six days per week, except during shutdown for construction or necessary maintenance, or as provided in item 23.

   a) If circumstances dictate the use of Ten Mile Creek water to meet water demands during periods that the turbidity exceeds 5.0 NTU the City will:

      i) immediately notify the department and receive its approval;

      ii) give public notice as required by ARM 16.20.227;

      iii) increase chlorination as required by the department.

3. A minimum chlorine residual of 0.3 mg/l will be maintained throughout the distribution system. The City will do monitoring of chlorine residuals throughout the system, and submit the results to the department. The monitoring will be done as in Phase I (Item 2).

C. WATER SYSTEM OPERATION - PHASE III (after expansion of MRTP to 9.75 MGD (June 1, 1984)

1. The Missouri River Plant will be operated at full capacity on a full-time basis to provide as much treated water to the City's users as possible except as provided in item 23 or for shutdown for construction or necessary maintenance.

2. The manual valves will be operated so that the Ten Mile System will be shut down at a turbidity of 5 NTU.

25. Describe your plan for interim control measures during the effective period of the exemption.

Phase I: Operate the Ten Mile System as long as it does not exceed 10 NTU. If it exceeds 10 NTU, the system will be shut down. The Missouri River Treatment Plant will provide a minimum of 1.8 million gallons per day for an average of six days per week, except during shutdown for construction or necessary maintenance. Adequate chlorine residuals (.3 mg/l total) will be maintained throughout the distribution system. Valves will be installed on the Ten Mile System to shut it down if 10 turbidity units are exceeded, except as provided in item 23.

Phase II: Operate the Ten Mile System as long as it does not exceed 5 NTU. If it exceeds 5 NTU, the system will be shut down. The Missouri River Treatment Plant will provide a minimum of 1.8 million gallons per day for an average of six days per week, except during shutdown for construction or necessary maintenance. Adequate chlorine residuals (.3 mg/l total) will be maintained throughout the distribution system. Valves on the Ten Mile System will shut it down if 5 turbidity units are exceeded, except as provided in this attachment, or as provided in item 23.

Phase III: After expansion of the Missouri River Treatment Plant, the plant will operate at full capacity at all times and the Ten Mile System will only be used if it does not exceed 5 NTU, except for the fire protection and as provided in item 23; or for shutdown for necessary maintenance.

Attachment "E"

27) COMPLIANCE SCHEDULE

		*MRTP	**TMTP
1)	Start of preliminary planning	Completed	Completed
2)	Completion of preliminary planning	Completed	Completed
3)	Start of final plans and specs	May 1982	35% Complete 10/13/80
4)	Completion of final plans and specs	Oct. 1982	June 1, 1985
5)	Obtaining construction funds	Dec. 1982	Completion Nov. 1, 1984
6)	Start of Construction	Mar. 1983	Sept. 1, 1985
7)	Completion of Construction	June 1, 1984	June 1, 1987
8)	Completion of a detailed O & M Manual	June 1, 1984	June 1, 1987
9)	Plant start-up	June 1, 1984	June 1, 1987

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* - Missouri River Treatment Plant Expansion to 9.75 MGD

**- Ten Mile Treatment Plant Construction

APPENDIX 4

DETAILED COST SUMMARIES

SUMMARY SHEET FOR CITY OF HELENA SUPPLY SYSTEM
CAPITAL AND ANNUAL COSTS - SECONDARY PLANT 334 million gallons per year — 11MGD

GROUNDWATER SUPPLY SYSTEM

OPTION 1

ITEM	INTEREST RATE	NUMBER OF YEARS	CAPITAL COST	ANNUAL COST (YR 1987)	ANNUAL COST (YR 2007)	ADJSTED ANNUAL COST
WELLS & PIPELINE CONST	10.0	15	$7,922,314.88	$1,178,516.68 (1)	$0.00	$1,052,895.34
MAINTENANCE & MISC (.5% of initial cost)	10.0	20		$39,611.57	$101,169.07	$60,325.18
POWER	10.0	20		$84,576.02	$200,974.70	$148,324.62
LABOR	10.0	20		$18,497.74	$47,243.75	$28,170.54
CHEMICALS	10.0	20		$1,007.00	$2,571.91	$1,533.58
		TOTALS	$7,922,314.88	$1,322,209.02	$351,959.42	$1,291,249.26

Annual capitol cost per mg = $3,152.38 Annual O&M cost per mg = $713.63

TEN-MILE SURFACE WATER TREATMENT PLANT SYSTEM — 11 MGD

OPTION 2

ITEM	INTEREST RATE	NUMBER OF YEARS	CAPITAL COST	ANNUAL COST (YR 1987)	ANNUAL COST (YR 2007)	ADJSTED ANNUAL COST
TREATMENT PLANT CONST.	10.0	15	$8,098,000.00	$1,204,651.44 (1)	$0.00	$1,076,244.33
BOOSTER STATION CONST.	10.0	15	$450,000.00	$66,941.61 (1)	$0.00	$59,806.12
CHESSMAN RES. REPAIR	10.0	15	$1,027,009.23	$152,777.00 (1)	$0.00	$136,492.08
MAINTENANCE	10.0	20		$23,646.00	$60,392.55	$36,010.92
POWER	10.0	20		$51,080.00	$130,459.75	$77,790.65
LABOR	10.0	20		$113,378.00	$289,570.59	$172,665.40
MISCELLANEOUS	10.0	20		$10,000.00	$25,540.28	$15,229.18
COST OF RAW WATER	10.0	20		$2,000.00	$5,108.06	$3,045.84
CHEMICALS	10.0	20		$21,988.00	$56,157.97	$33,485.92
		TOTALS	$9,575,009.23	$1,646,462.05	$567,229.19	$1,610,770.43

Annual capitol cost per mg = $3,810.01 Annual O&M cost per mg = $1,012.66

(1) BOND RESERVE CAPITALIZED IN BOND ISSUE

MISSOURI RIVER TREATMENT PLANT 1888 million gallons per year - 9MGD

ITEM	INTEREST RATE	NUMBER OF YEARS	CAPITAL COST	ANNUAL COST	ANNUAL COST (YR 2007)	ADJSTED ANNUAL COST
PLANT EXPANSION	9.2	20	$2,650,300.00	$392,565.96 (1)	$0.00	$335,834.59
20 IN PIPE CONSTRUCTION	9.2	20	$1,216,300.00	$180,180.37 (1)	$0.00	$154,141.74
PLANT RENOVATION	9.8	20	$1,055,000.00	$163,673.36 (1)	$0.00	$141,232.28
MAINTENANCE	10.0	20		$10,819.00	$27,632.03	$16,476.45
POWER	10.0	20		$375,797.00	$959,796.06	$572,308.02
LABOR	10.0	20		$161,746.00	$413,103.81	$246,325.90
MISCELLANEOUS	10.0	20		$10,000.00	$25,540.28	$15,229.18
COST OF RAW WATER	10.0	20		$82,406.00	$210,467.23	$125,497.58
CHEMICALS	10.0	20		$104,694.00	$267,391.41	$159,440.38
		TOTALS	$4,921,600.00	$1,481,881.69	$1,903,930.82	$1,766,486.11

OPTIONS 1&2

Annual capitol cost per mg = $334.33 Annual O&M cost per mg = $601.31

(1) BOND RESERVE CAPITALIZED IN BOND ISSUE

MISSOURI RIVER TREATMENT PLANT 279 million gallons per year — 9MGD

OPTIONS 3a & 4

ITEM	INTEREST RATE	NUMBER OF YEARS	CAPITAL COST	ANNUAL COST	ANNUAL COST (YR 2007)	ADJSTED ANNUAL COST
PLANT EXPANSION	9.2	20	$2,650,300.00	$392,565.96 (1)	$0.00	$335,834.59
20 IN PIPE CONSTRUCTION	9.2	20	$1,216,300.00	$180,180.37 (1)	$0.00	$154,141.74
PLANT RENOVATION	9.8	20	$1,055,000.00	$163,673.36 (1)	$0.00	$141,232.28
MAINTENANCE	10.0	20		$10,819.00	$27,632.03	$16,476.45
POWER	10.0	20		$191,481.00	$489,047.83	$291,609.86
LABOR	10.0	20		$43,035.00	$109,912.59	$65,538.78
MISCELLANEOUS	10.0	20		$10,000.00	$25,540.28	$15,229.18
COST OF RAW WATER	10.0	20		$13,311.00	$33,996.67	$20,271.56
CHEMICALS	10.0	20		$13,569.00	$34,655.61	$20,664.47
		TOTALS	$4,921,600.00	$1,018,634.69	$720,785.01	$1,060,998.92

Annual capitol cost per mg = $2,262.40 Annual O&M cost per mg = $1,540.47

(1) BOND RESERVE CAPITALIZED IN BOND ISSUE

MISSOURI RIVER TREATMENT PLANT 333 million gallons per year – 9 MGD

OPTION 3b

ITEM	INTEREST RATE	NUMBER OF YEARS	CAPITAL COST	ANNUAL COST	ANNUAL COST (YR 2007)	ADJSTED ANNUAL COST
PLANT EXPANSION	9.2	20	$2,650,300.00	$392,565.96 (1)	$0.00	$335,834.59
20 IN PIPE CONSTRUCTION	9.2	20	$1,216,300.00	$180,180.37 (1)	$0.00	$154,141.74
PLANT RENOVATION	9.8	20	$1,055,000.00	$163,673.36 (1)	$0.00	$141,232.28
MAINTENANCE	10.0	20		$10,819.00	$27,632.03	$16,476.45
POWER	10.0	20		$200,500.00	$512,082.61	$305,345.06
LABOR	10.0	20		$48,751.00	$124,511.42	$74,243.78
MISCELLANEOUS	10.0	20		$10,000.00	$25,540.28	$15,229.18
COST OF RAW WATER	10.0	20		$15,618.00	$39,888.81	$23,784.93
CHEMICALS	10.0	20		$17,163.00	$43,834.78	$26,137.84
		TOTALS	$4,921,600.00	$1,039,270.69	$773,489.93	$1,092,425.85

Annual capitol cost per mg = $1,895.52 Annual O&M cost per mg = $1,385.04

(1) BOND RESERVE CAPITALIZED IN BOND ISSUE

(2) CAPITAL COST DISCOUNTED TO REFLECT CONSTRUCTION IN 2002

SUMMARY SHEET FOR CITY OF HELENA SUPPLY SYSTEM
CAPITAL AND ANNUAL COSTS - PRIMARY PLANTS 1943 million gallons per year – 11 MGD

GROUNDWATER SUPPLY SYSTEM

ITEM	INTEREST RATE	NUMBER OF YEARS	CAPITAL COST	ANNUAL COST (YR 1987)	ANNUAL COST (YR 2007)	ADJSTED ANNUAL COST
WELLS & PIPELINE CONST	10.0	15	$7,922,314.88	$1,178,516.68 (1)	$0.00	$1,052,895.34
MAINTENANCE & MISC (.5% of initial cost)	10.0	20		$39,611.57	$101,169.07	$60,325.18
POWER	10.0	20		$458,044.84	$1,088,434.04	$670,165.77
LABOR	10.0	20		$18,497.74	$47,243.75	$28,170.54
CHEMICALS	10.0	20		$5,856.00	$14,956.39	$8,918.21
		TOTALS	$7,922,314.88	$1,700,526.83	$1,251,803.24	$1,820,475.03

Annual capital cost per mg = $541.89 Annual O&M cost per mg = $395.05

OPTION 4

TEN-MILE SURFACE WATER TREATMENT PLANT SYSTEM – 11 MGD

ITEM	INTEREST RATE	NUMBER OF YEARS	CAPITAL COST	ANNUAL COST (YR 1987)	ANNUAL COST (YR 2007)	ADJSTED ANNUAL COST
TREATMENT PLANT CONST.	10.0	15	$8,098,000.00	$1,204,651.44 (1)	$0.00	$1,076,244.33
BOOSTER STATION CONST.	10.0	15	$450,000.00	$66,941.61 (1)	$0.00	$59,806.12
CHESSMAN RES. REPAIR	10.0	15	$1,027,009.23	$152,777.00 (1)	$0.00	$136,492.08
MAINTENANCE	10.0	20		$23,646.00	$60,392.55	$36,010.92
POWER	10.0	20		$102,325.00	$261,340.91	$155,832.58
LABOR	10.0	20		$113,378.00	$289,570.59	$172,665.40
MISCELLANEOUS	10.0	20		$10,000.00	$25,540.28	$15,229.18
COST OF RAW WATER	10.0	20		$2,000.00	$5,108.06	$3,045.84
CHEMICALS	10.0	20		$113,112.00	$288,891.21	$172,260.30
		TOTALS	$9,575,009.23	$1,788,831.05	$930,843.60	$1,827,586.74

Annual capitol cost per mg = $654.94 Annual O&M cost per mg = $285.66

OPTION 3a & 5w

(1) BOND RESERVE CAPITALIZED IN BOND ISSUE

SUMMARY SHEET FOR CITY OF HELENA SUPPLY SYSTEM
CAPITAL AND ANNUAL COSTS - PRIMARY PLANTS 1889 million gallons per year – 11 MGD

GROUNDWATER SUPPLY SYSTEM

ITEM	INTEREST RATE	NUMBER OF YEARS	CAPITAL COST	ANNUAL COST (YR 1987)	ANNUAL COST (YR 2007)	ADJSTED ANNUAL COST
WELLS & PIPELINE CONST	10.0	15	$7,922,314.88	$1,178,516.68 (1)	$0.00	$1,052,895.34
MAINTENANCE & MISC (.5% of initial cost)	10.0	20		$39,611.57	$101,169.07	$60,325.18
POWER	10.0	20		$458,044.84	$1,088,434.04	$670,165.77
LABOR	10.0	20		$18,497.74	$47,243.75	$28,170.54
CHEMICALS	10.0	20		$5,856.00	$14,956.39	$8,918.21
		TOTALS	$7,922,314.88	$1,700,526.83	$1,251,803.24	$1,820,475.03

Annual capital cost per mg = $557.38 Annual O&M cost per mg = $406.34

OPTION 4

TEN-MILE SURFACE WATER TREATMENT PLANT SYSTEM – 10 MGD w/ 11 MGD BOOSTERS

ITEM	INTEREST RATE	NUMBER OF YEARS	CAPITAL COST	ANNUAL COST (YR 1987)	ANNUAL COST (YR 2007)	ADJSTED ANNUAL COST
TREATMENT PLANT CONST.	10.0	15	$7,793,000.00	$1,159,279.91 (1)	$0.00	$1,035,709.07
BOOSTER STATION CONST.	10.0	15	$450,000.00	$66,941.61 (1)	$0.00	$59,806.12
MAINTENANCE	10.0	20		$22,756.00	$58,119.46	$34,655.52
POWER	10.0	20		$100,977.00	$257,898.08	$153,779.69
LABOR	10.0	20		$113,378.00	$289,570.59	$172,665.40
MISCELLANEOUS	10.0	20		$10,000.00	$25,540.28	$15,229.18
COST OF RAW WATER	10.0	20		$2,000.00	$5,108.06	$3,045.84
CHEMICALS	10.0	20		$109,519.00	$279,714.59	$166,788.46
		TOTALS	$8,243,000.00	$1,584,851.52	$915,951.06	$1,641,679.27

Annual capitol cost per mg = $579.94 Annual O&M cost per mg = $289.13

OPTION 3b & 5b

(1) BOND RESERVE CAPITALIZED IN BOND ISSUE

SUMMARY SHEET FOR CITY OF HELENA SUPPLY SYSTEM
CAPITAL AND ANNUAL COSTS - SECONDARY PLANT 279 million gallons per year

OPTION 5a

GROUNDWATER SUPPLY SYSTEM

ITEM	INTEREST RATE	NUMBER OF YEARS	CAPITAL COST	ANNUAL COST (YR 1987)	ANNUAL COST (YR 2007)	ADJSTED ANNUAL COST
WELLS & PIPELINE CONST	10.0	15	$1,202,162.97	$178,832.72 (1)	$0.00	$159,770.45
MAINTENANCE & MISC (.5% of initial cost)	10.0	20		$6,010.81	$15,351.79	$9,153.98
POWER	10.0	20		$113,886.46	$270,623.94	$159,423.90
LABOR	10.0	20		$18,497.74	$47,243.75	$28,170.54
CHEMICALS	10.0	20		$1,007.00	$2,571.91	$1,533.58
		TOTALS	$1,202,162.97	$318,234.73	$335,791.38	$358,052.45

Annual capitol cost per mg = $572.65 Annual O&M cost per mg = $710.69

MISSOURI RIVER TREATMENT PLANT 279 million gallons per year

ITEM	INTEREST RATE	NUMBER OF YEARS	CAPITAL COST	ANNUAL COST	ANNUAL COST (YR 2007)	ADJSTED ANNUAL COST
PLANT EXPANSION	9.2	20	$2,650,300.00	$392,565.96 (1)	$0.00	$335,834.59
20 IN PIPE CONSTRUCTION	9.2	20	$1,216,300.00	$180,180.37 (1)	$0.00	$154,141.74
PLANT RENOVATION	9.8	20	$1,055,000.00	$163,673.36 (1)	$0.00	$141,232.28
MAINTENANCE	10.0	20		$10,819.00	$27,632.03	$16,476.45
POWER	10.0	20		$191,481.00	$489,047.83	$291,609.86
LABOR	10.0	20		$43,035.00	$109,912.59	$65,538.78
MISCELLANEOUS	10.0	20		$10,000.00	$25,540.28	$15,229.18
COST OF RAW WATER	10.0	20		$13,311.00	$33,996.67	$20,271.56
CHEMICALS	10.0	20		$13,569.00	$34,655.61	$20,664.47
		TOTALS	$4,921,600.00	$1,018,634.69	$720,785.01	$1,060,998.92

Annual capitol cost per mg = $2,262.40 Annual O&M cost per mg = $1,540.47

(2) BOND RESERVE CAPITALIZED IN BOND ISSUE

SUMMARY SHEET FOR CITY OF HELENA SUPPLY SYSTEM
CAPITAL AND ANNUAL COSTS - SECONDARY PLANT 333 million gallons per year

OPTION 5b

GROUNDWATER SUPPLY SYSTEM

ITEM	INTEREST RATE	NUMBER OF YEARS	CAPITAL COST	ANNUAL COST (YR 1987)	ANNUAL COST (YR 2007)	ADJSTED ANNUAL COST
WELLS & PIPELINE CONST	10.0	15	$1,202,162.97	$178,832.72 (1)	$0.00	$159,770.45
MAINTENANCE & MISC (.5% of initial cost)	10.0	20		$6,010.81	$15,351.79	$9,153.98
POWER	10.0	20		$135,929.06	$323,002.92	$217,013.38
LABOR	10.0	20		$18,497.74	$47,243.75	$28,170.54
CHEMICALS	10.0	20		$1,007.00	$2,571.91	$1,533.58
		TOTALS	$1,202,162.97	$340,277.34	$388,170.36	$415,641.93

Annual capital cost per mg = $479.79 Annual O&M cost per mg = $768.38

(1) BOND RESERVE CAPITALIZED IN BOND ISSUE

MISSOURI RIVER TREATMENT PLANT 333 million gallons per year

ITEM	INTEREST RATE	NUMBER OF YEARS	CAPITAL COST	ANNUAL COST	ANNUAL COST (YR 2007)	ADJSTED ANNUAL COST
PLANT EXPANSION	9.2	20	$2,650,300.00	$392,565.96 (1)	$0.00	$335,834.59
20 IN PIPE CONSTRUCTION	9.2	20	$1,216,300.00	$180,180.37 (1)	$0.00	$154,141.74
PLANT RENOVATION	9.8	20	$1,055,000.00	$163,673.36 (1)	$0.00	$141,232.28
MAINTENANCE	10.0	20		$10,819.00	$27,632.03	$16,476.45
POWER	10.0	20		$200,500.00	$512,082.61	$305,345.06
LABOR	10.0	20		$48,751.00	$124,511.42	$74,243.78
MISCELLANEOUS	10.0	20		$10,000.00	$25,540.28	$15,229.18
COST OF RAW WATER	10.0	20		$15,618.00	$39,888.81	$23,784.93
CHEMICALS	10.0	20		$17,163.00	$43,834.78	$26,137.84
		TOTALS	$4,921,600.00	$1,039,270.69	$773,489.93	$1,092,425.85

Annual capitol cost per mg = $1,895.52 Annual O&M cost per mg = $1,385.04

(1) BOND RESERVE CAPITALIZED IN BOND ISSUE

APPENDIX 5

ANALYSIS OF TREATMENT OPTIONS FOR TEN MILE CREEK WATER TREATMENT PLANT

msu DEPARTMENT OF CIVIL ENGINEERING & ENGINEERING MECHANICS

COLLEGE OF ENGINEERING MONTANA STATE UNIVERSITY. BOZEMAN 59717

June 20, 1984

Mr. James M. Gillie
Civil Engineer
Hydrometrics
2727 Airport Road
Helena, MT 59601

Dear Jim:

Enclosed herewith is my preliminary assessment of the Ten Mile Creek Raw Water for Direct Filtration. I think pilot studies should be run prior to any decision to build a full scale treatment plant. The algae in the water is probably the cause of the taste and odor problem and the only limitation for direct filtration. An alternative engineering approach would be to construct the treatment plant in phases; initially, the filters alone with the layout allowing for the flocculation-sedimentation units if they become necessary.

Please feel free to contact me if you need any additional information.

Yours sincerely,

A. Amirtharajah
Professor

AA/mem

Enclosure

TELEPHONE (406) 994 2111

Analysis of Treatment Options for Ten Mile Creek Water Treatment Plant

by

A. Amirtharajah
Professor of Civil Engineering
Montana State University
Bozeman, MT. 59717

I. Analysis of Raw water Source

The current Ten Mile Creek Water Supply has disinfection as the only treatment process. Table 1 shows data on finished water quality over a two year period. The turbidity has always been less than 8.5 T.U. during this period. Some records indicate that the turbidity rises to levels of 13 to 19 NTU after an intense rainstorm. Color in the water has not been significantly high. The water also has pH in the range of 6.0 to 6.8 and algae counts of the order of 1533 to 9530 cells/ml. The alkalinity and hardness of the water is very low in the range of 14-64 mg/l as $CaCO_3$.

II. Direct Filtration as a Treatment Scheme

A literature review (1) has indicated the limiting parameters which control the selection of direct filtration as a treatment option. The "perfect candidate" raw waters for direct filtration are those with the following limits on quality:

Color < 40 c.u.
Turbidity < 5 NTU
Algae < 2000 asu/ml
Iron < 0.3 mg/l
Manganese < 0.05 mg/l

Some authorities (1) indicate that the above limitations are far too conservative and that turbidities up to 25 NTU can be tolerated in direct filtration schemes provided the alum dosages required for treatment are less than 15 mg/l.

Amirtharajah and Suprenant (1) have shown how the Alum Coagulation Diagram could be used to select the chemical dosages required for direct filtration. Fig. 1 shows the region where alum coagulation will be effective.

The raw water quality parameters of the Ten Mile Creek supply based on Table 1 indicates that the water is probably highly suited to direct filtration except for the algae counts. The low alkalinity and pH in the range of 6.0 - 6.8 suggest that low alum dosages will be very effective in destabilizing the particles for direct filtration.

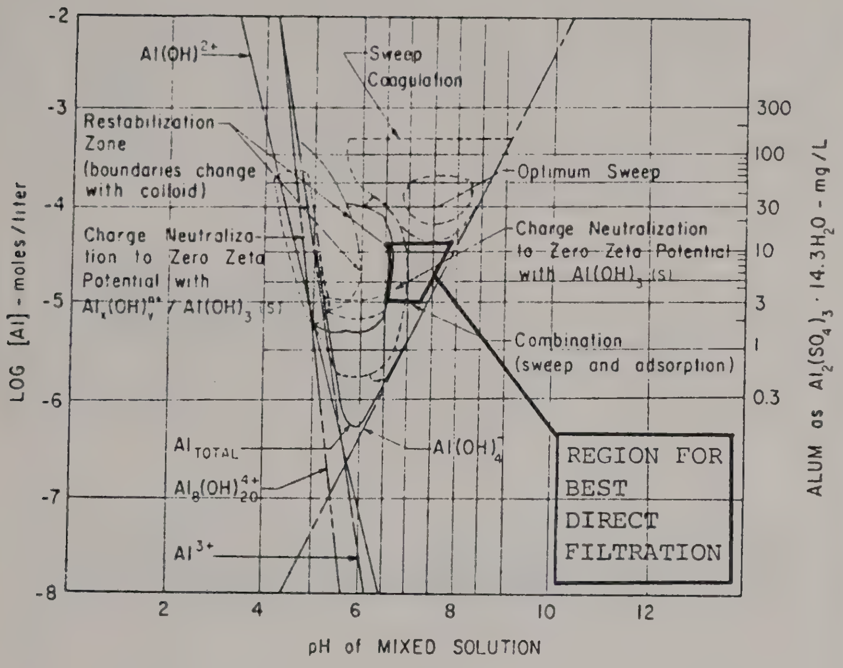

Fig. 1 . THE REGION FOR "BEST" DIRECT FILTRATION ON THE ALUM COAGULATION DIAGRAM.

Table I. Ten Mile Creek Finished Water Quality Data.

Month	Turbidity - N.T.U.			Typical pH	Total Algae Counts - cells/ml	Alkalinity - mg/l as $CaCO_3$	Hardness -mg/l as $CaCO_3$
	High	Low	Mean				
April '84	4.3	2.8	3.5	6.1			
March '84	3.3	2.3	3.0	6.1	1533	≃ 14^1	≃ 19^1
Feb. '84	3.4	2.9	3.1	6.1	2667	26^2	64^2
Jan. '84	4.8	2.9	3.5	6.1	8070		
Dec. '83	3.7	2.3	2.8	6.0	7830		
Nov. '83	3.2	1.9	2.5	6.1	7870		
Oct. '83	3.0	1.9	2.3	6.2	9530		
Sept. '83	5.0	2.2	3.2	6.2	6600		
Aug. '83	3.7	1.9	2.6	6.2			
July '83	5.7	1.8	2.7	6.0			
June '83	4.7	1.7	2.5	6.0			
May '83	6.7	2.5	3.9	6.3			
April '83	7.5	1.9	3.3	6.6			
March '83	3.4	1.4	2.3	6.6			
Feb. '83	2.1	1.2	1.5	6.5			
Jan. '83	1.8	1.4	1.6	6.5			
Dec. '82	2.1	1.5	1.7	6.4			
Nov. '82	2.5	1.4	1.7	6.8			
Oct. '82	3.1	1.1	1.9	6.8			
Sept. '82	6.1	1.9	3.2	6.8			
Aug. '82	6.1	2.0	2.6	6.8			
July '82	8.5	1.3	2.6	6.8			
June '82	4.8	1.7	2.7	6.8			
May '82	4.8	2.4	3.1	6.8			

Notes: [1] data from 1980.

[2] data from 1977.

III. Algae as a Limiting Parameter

The algal counts in the Ten Mile Creek Supply are in the range of 1533 to 9530 cells/ml which are significantly above the requirements of 2000 asu/ml for the perfect candidate waters. The algal count studies indicate that a large fraction of the algae (60 to 80%) are the species Oocystis. The filter clogging algae such as Diatoma and Chlorella are much smaller in numbers. In order to evaluate the effect of high numbers in Oocystis it will be necessary to run some pilot studies to determine their effect on filter runs. A possible alternative would be the specific design of the media to accommodate the removal of these algae. Another approach would be to determine some means of reservoir management such that the algae counts are reduced or not drawn into the raw water conduit.

IV. Conclusions

The Ten Mile Creek Water Supply source has a water ideally suitable for direct filtration, except for the high algae count. It is recommended that pilot studies be seriously considered to evaluate the suitability of direct filtration for filtering these algae.

Reference

(1) Amirtharajah, A. and Bryan K. Suprenant, "Direct Filtration Using the Alum Coagulation Diagram" presented at the Annual Conference of the American Water Works Association, June 10-14, 1984, Dallas, Texas.

APPENDIX 6.

TURBIDITY OF TENMILE CREEK SUPPLY HEADGATES

GUARDIAN OF THE GULCH

City of Helena

Commissioners
Russell J. Ritter, Mayor
Rayleen Beaton
Michael J. DaSilva
Joan A. Duncan
Dale L. Johnson

Robert A. Erickson
City Manager

City-County Admin. Bldg.
316 North Park
Helena, MT 59623

Phone 406/442-9920

Lewis & Clark Library
120 S. Last Chance Gulch
Helena

TO: MORRISON-MAIERLE, INC.

FROM: Lyle Griffiths, Chief Operator, 10-Mile System

DATE: July 15, 1984

SUBJ: Turbidity at Headgates

In regards to Turbidity at the headgates during a rain storm. This will vary depending on the intensity of the storm. Ten Mile headgate appears to have the worst turbidity problem, this is due partly because of the road above 10-Mile headgate. After the flood of 1981 the road was built up and during a heavy rain this water runs off the road and into the headgate. During a heavy rain accompanied by hail, this headgate has reached turbidity of 400 to 500. This rarely happens but is not uncommon in that area. During a more average storm NTU will reach between 20 and 70, and this is what we normaly have. This headgate also has our largest volume of water, either free water or from Scott Res. After a normal storm this headgate takes approximately 6 hours to clear up so it can be put into the system again.

Beaver Creek headgate also lies in the same area as 10-Mile headgate, and this headgate is in the same range as our 10-Mile headgate for NTU during a storm. This may be due to the fact that this water shed lies in the Red Mountain area and has many small feeder creeks that dump into Beaver Creek, which is collected at our Beaver Creek headgate.

Moose Creek headgate is our smallest headgate and has the least amount of water during the summer and winter months. This headgate is fed by a small Beaver Dam approximately three quarters of a mile from the headgate. During a rain storm this water is more discolored than it is high in turbidity, and is usely in the high 20 to 30 range for NTU.

Minniehaha Creek is our best source of quality water in reference to NTU average. It is also one of the smallest, but like Moose Creek it clears up varely fast after a storm. Minniehaha and Moose do not receive as many storms or the intensity that 10-Mile and Beaver Creek do. After a storm NTU is in the range of 10 to 20 at Minniehaha but has been higher after an unusual severe storm which is seldom seen in this area.

Walker Creek headgate appears to have the poorest quality water due to the Coliform problem. This headgate is not normaly used, except on rare occassions such as the flood of 1981. This headgate is not monitored in the winter months because of snow and it is not under normal conditions being used. This headgate has a high turbidity average in comparison to the other headgates.

Ten Mile is the largest producer of water, then Beaver, Minniehaha, Moose and Walker Creek.

Lyle Griffiths
Lyle Griffiths
Chief Operator, 10-Mile System

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